MACHINERY.

May, 1905.

MODERN STEAM HOISTING MACHINERY.

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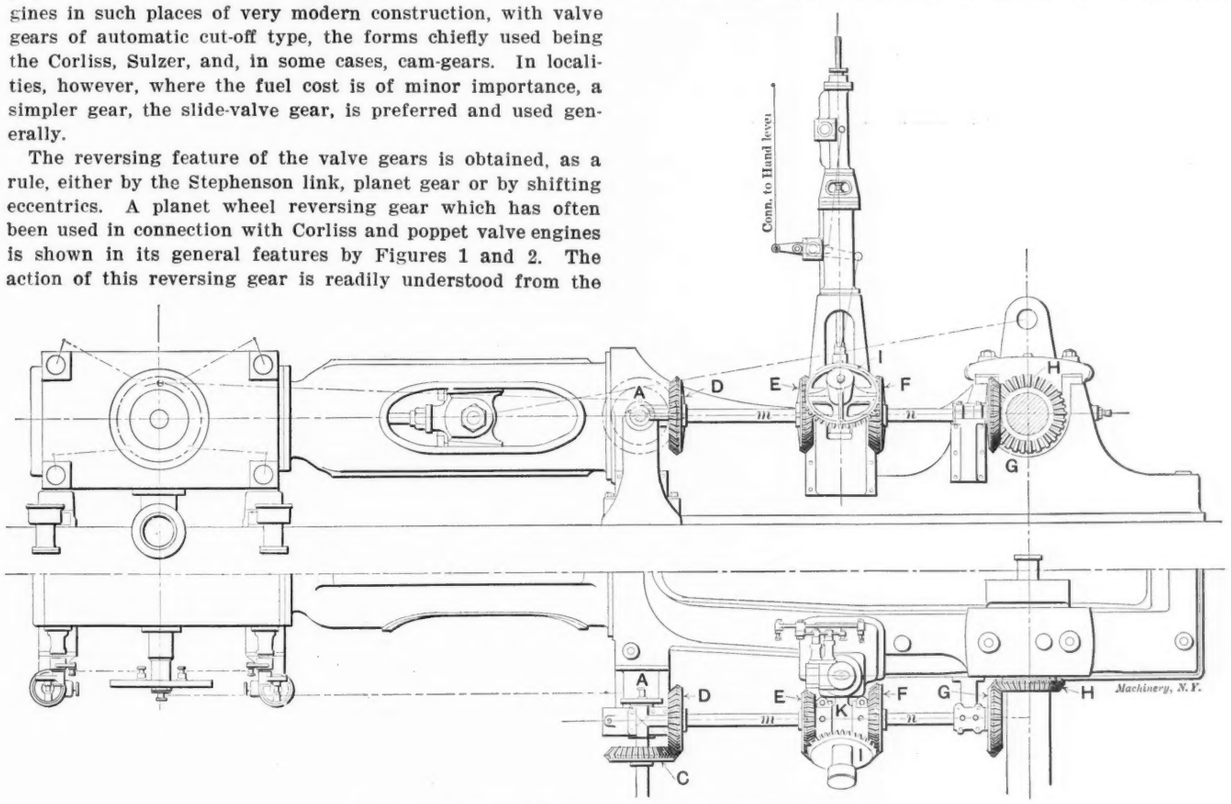
Few classes of steam machinery, perhaps, include so many interesting details of construction as does the modern hoisting engine; the following description of some features of its design and auxiliaries, therefore, may not be without interest. In regard to the details of the engine proper but little can be said, as in this respect the hoisting engine does not differ materially from the steam engine in general; the valve gears principally employed in connection with hoisting engines, however, merit special account.

Economy in the consumption of fuel being generally an important consideration in mining districts, we find hoisting engines in such places of very modern construction, with valve gears of automatic cut-off type, the forms chiefly used being the Corliss, Sulzer, and, in some cases, cam-gears. In localities, however, where the fuel cost is of minor importance, a simpler gear, the slide-valve gear, is preferred and used generally.

The reversing feature of the valve gears is obtained, as a rule, either by the Stephenson link, planet gear or by shifting eccentrics. A planet wheel reversing gear which has often been used in connection with Corliss and poppet valve engines is shown in its general features by Figures 1 and 2. The action of this reversing gear is readily understood from the figures, if we note that what is required, in order to obtain a reversed motion of the engine, is simply to shift the driving pin *A*, relatively to the crank, through an angle of 180 degrees minus twice the angle of advance; the pin *A* being directly connected with the wrist plate. This shifting is performed by means of the bevel gears, *C*, *D*, and *E*, which are all rotated the required angle, relatively to the gears *F*, *G*, and *H*, when reversing. The reverse lever *K*, mounted on trunnions in the center line, *m-n* of the driving gears, performs the shifting of the gears by means of the planet gear, *I*, which is journaled on the end of the lever. If we suppose that the gear *F* is stationary, and that we swing the reverse lever, together with the gear mounted on it, through a certain angle, the effect will be to rotate the gear *E* through an angle of twice the amount to which the reverse lever is swung. The reverse engine is, therefore, required to swing the lever through an angle of ½ (180 degrees — 2 × angle of advance), or somewhat less than 90 degrees.

The space on the engine shaft occupied by the driving gears being generally somewhat greater than that which would be required by two eccentrics connected to a link, the principal claim of advantage, in using this type of reversing mechanism in connection with Corliss engines, is the fact that it gives an invariable motion to the wrist-plate. A link motion, properly laid out, however, will give results which are fully acceptable in this respect, and it will usually make a simpler and neater arrangement as well. In connection with poppet valve or Sulzer gears, however, the planet-wheel reversing gear makes a suitable arrangement.



Figs. 1 and 2. Hoisting Engine with Planet Wheel Reversing Gear.

The Power of Hoisting Engines.

For the sake of clearness it is most convenient to consider direct-connected or first-motion and geared hoists separately.

FIRST-MOTION HOISTS.

The size of the cylinders is determined by the maximum power required to raise the total load, at any point in the course of its elevation. The power required to raise the load when the cage is at the bottom level will be a maximum, due to the unbalanced lead of rope, if the hoisting drum is

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cylindrical. In the case of a conical drum, or a flat rope reel, the point at which the maximum lifting moment is required depends on the ratio between the large and small diameter of the drum and on the depth from which the load is elevated. Conical drums or reels are, however, seldom designed so as to fully compensate for the weight of the rope, so that, as a rule, the maximum moment of the load occurs, even in the case of such drums, when the load is at the bottom level. Having ascertained what the maximum moment of the load is, the areas of cylinders are proportioned so that the work generated during one revolution of the engine equals that required to wind up the load the distance corresponding to one turn of the drum, plus the work due to frictional resistance. An average value of the friction loss is 20 per cent of the theoretical power of the engine, which amount should not be exceeded under ordinary circumstances. We get, therefore:

$$L\,c = 0.8\,A\,P_{\text{m max.}}\,2\,s \qquad (1)$$

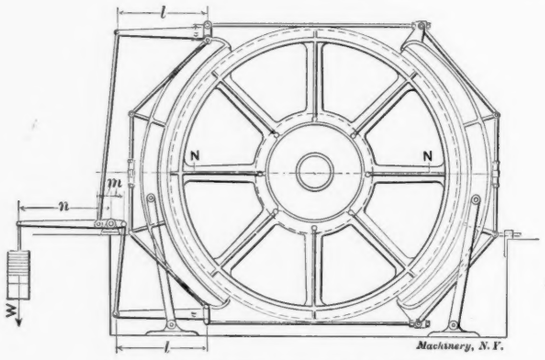

Fig. 3. Type of Brake supported by Links.

where L = maximum unbalanced load to be raised, in pounds. In a double-cage hoist one loaded cage must often be raised, without being counterbalanced by the other, when L would equal the sum of the weights of cage, load and rope.

D = diameter of drum in feet, at a point where the maximum load occurs.

A = total cylinder area in square inches; in case of two cylinders, the area of both.

S = length of stroke of piston in feet.

c = circumference of drum = 3.14 D.

$P_{\text{m max.}}$ = mean pressure in cylinder at a late cut-off, in pounds.

This mean pressure can properly be estimated at

$$P_{\text{m max.}} = \begin{cases} 0.9\ P \text{ for slide valve engines.} \\ 0.7\ P \text{ for Corliss engines.} \end{cases}$$

if P = boiler pressure.

Inserting these values in equation 1 we get

$$L = 0.5\,A\,s\,\frac{0.9\,P\text{-}b}{D} \qquad (2)$$

$$A = 2\,\frac{D\,L}{(0.9\,P\text{-}b)\,s} \qquad (3)$$

} for slide valve engines.

$$L = 0.5\,A\,s\,\frac{0.7\,P\text{-}b}{D} \qquad (4)$$

$$A = 2\,\frac{D\,L}{(0.7\,P\text{-}b)\,s} \qquad (5)$$

} for Corliss and Sulzer engines.

where b = the back pressure in the cylinders.

In estimating the horse power required to run a certain load at a required speed in a mine shaft, the resistance due to the wind pressure acting on the cage must be considered as well as the frictional resistances in the engine. This may sometimes be considerable. To cover both this resistance and the engine friction from 25 per cent to 40 per cent of the theoretical horse power should be added, and we get therefore:

$$H\,P = 1.25 \text{ to } 1.4\,\frac{L}{33{,}000}\,h \qquad (6)$$

where $H\,P$ = the maximum horse power required if L is the maximum unbalanced load, and h = the speed of the cage in feet per minute.

The cross section of one cylinder which would be required in order to start the load if one crank gets on dead center, is:

$a = 1.11\,\frac{D\,L}{s\,(P\text{-}b)}$ (7) in which equation 10 per cent has been allowed for friction in the engine journals and for the stiffness in the rope. This area is practically the same as is required for a slide valve engine, according to equation 3.

Equation 7 shows that the sizes of the cylinders as determined from equations 3 and 5 will also be ample to start the load, if the positions of the cranks happen to be such as to require one engine alone to do the work momentarily.

Having determined the sizes of the cylinders for a hoist according to the foregoing formulas, which are as a rule considered sufficient for this purpose, it might be that such a hoist would, under some circumstances, be too slow in practical operation. It would be well, therefore, to ascertain how the engine would meet the requirements of speed in each case.

Generally the maximum unbalanced load is far in excess of the load which the engine is required to handle under average circumstances, and, therefore, the question of speed when working under exceptional requirements does not carry much importance. In a case where the maximum unbalanced load is also the one which is most generally occurring, however, the cylinders as determined by equations 3 and 6 may be too small.

The following method of computation can be used when it is desired to ascertain the actual time that will be required for *speeding up* to the normal velocity which has been decided upon.

The energy developed by the engine during the time t, when speeding up the load from a velocity of o to a velocity v, is:

$$\frac{A\,\mu\,P\,s\,v\,t}{\pi\,D} \text{ foot pounds.}$$

where $\mu\,P$ = mean effective pressure in the cylinders.

This energy is expended in:

(1) Acceleration of the total unbalanced load $= \frac{1}{2}\,\frac{L}{g}\,v^2$,

(2) Acceleration of the rope drum $= 2\,I\,\frac{v^2}{D^2}$,

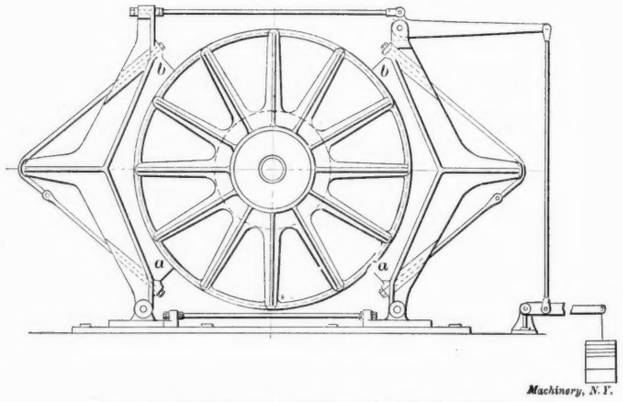

Fig. 4. Simpler but Less Successful Type of Brake.

where I = moment of inertia of the rope drum, and

(3) Lifting the load $= \frac{1}{2}\,v\,t\,L$

We get therefore:

$$\frac{A\,\mu\,P\,s\,v\,t}{\pi\,D} = \frac{1}{2}\,\frac{L}{g}\,v^2 + 2\,I\,\frac{v^2}{D^2} + \frac{1}{2}\,v\,t\,L.$$

I, the moment of inertia, $= \frac{W}{g}\,\rho^2$

where ρ = the radius of gyration of the drum and W = the weight of the rope drum.

Inserting this value for I and solving for t we get:

$$t = \frac{\pi D v \left(L + \frac{4}{D^2} W \rho^2\right)}{g (2 \mu P A s - \pi D L)} \qquad (8)$$

All symbols in the above expression represent known quantities, except ρ. The latter can be obtained exactly only after the design of the drum has been decided upon, but an approximate value in terms of the diameter of the drum can now be given within limits close enough for practical purposes.

We can say that: For cylindrical drums $\rho = 0.9 \frac{D}{2}$

For conical drums $\rho = 1.1 \frac{D}{2}$

For rope reels $\rho = 1.2 \frac{D}{2}$

In the case of conical drums and rope reels D means the small diameter, as this is the diameter of the winding of the rope when the cage is started from the bottom level, and the diameter to which the value of ρ is best referred.

With the above assumptions we get

$$\rho^2 = 0.8 \frac{D^2}{4} \text{ and } 1.4 \frac{D^2}{4},$$

respectively, for cylindrical drums and rope reels, with an intermediate value for conical drums.

These approximate values for ρ inserted in equation (8) give

$$t = \frac{\pi D v [L + (0.8 \text{ to } 1.4)\ W]}{g (2 \mu P A s - \pi D L)} \qquad (9)$$

From this equation it is convenient to get an approximate value of t. If this time for speeding up should appear unnecessarily long, we may properly increase the size of the cylinders somewhat, in order to obtain better results. It should be noted that μP, in the above formula, is to be taken only a little less than the initial effective pressure as, in starting, the engines would generally take steam full stroke, until the governor was up to speed and commenced to cut off.

As an example to the above we may take an actual case of a four-cylinder hoist, with a drum partly conical and partly cylindrical. The data are as follows:

Cylinders 34 inches in diameter × 5 foot stroke.

Total area of cylinders = 3,600 square inches.

Load, including rope, cage, cars and ore = 42,000 pounds.

Weight of drum, 250,000 pounds.

Small diameter of drum, 18 feet.

Normal speed of cage, 50 feet per second.

The drum being in this case of special construction, we call $\rho^2 = 1.1 \frac{D^2}{4}$.

Initial steam pressure = 120 pounds by the gage.

For a non-condensing engine, therefore, an average value of μP would be 100 pounds, and the time during which the engines are speeded up is

$$t = \frac{3.14 \times 50 \times 18\ (42{,}000 + 1.1 \times 250{,}000)}{32\ (2 \times 100 \times 3600 \times 5 - 3.14 \times 18 \times 42{,}000)} \text{ or}$$

$t = 23$ sec.

GEARED HOISTS.

The size of cylinders required for a geared hoist would evidently be the same as that required for a first-motion hoist multiplied by the ratio of the radius of the pinion to the radius of the gear, if it were not for the fact that the friction in the geared hoist would be greater than the friction in the direct-connected one. Taking this into consideration, and allowing 25 per cent of the total power developed for friction, we get:

$$L = 0.48 \frac{(0.9 P - b) A s R}{D r} \qquad (10)$$

$$A = 2.1 \frac{D L r}{(0.9 P - b) s R} \qquad (11)$$

} for slide-valve engines.

$$L = 0.48 \frac{(0.7 P - b) A s R}{D r} \qquad (12)$$

$$A = 2.1 \frac{D L r}{(0.7 P - b) s R} \qquad (13)$$

} for Corliss and Sulzer engines.

where r = the radius of the pinion.

R = the radius of the gear.

Brakes.

The brakes variously used on the modern hoisting engines are chiefly of two kinds: The band-brake, consisting of a wood- or fiber-lagged steel band, which tightens around a cast-iron brake drum, and the post-brake; this latter consists, as shown in Fig. 3, of two opposing wood-lagged upright beams which are pressed against the brake drum by means of steel rods passing between them. The second form of brake has the advantage that it is more quickly relagged with wood when occasion demands, and that the frictional shoes do not encircle the entire drum; for this reason the brake runs cooler than the band-brake. The post-brake has frequently been constructed as shown in Fig. 4, but this construction is not to be recommended. When carefully adjusted, and left in such condition, this brake may give good satisfaction, but after any careless readjustment of the beams, when the wood lining has worn down, the setting of the brake is liable to cause the brake-beam to grip hard at the bottom of the wood shoe at a. After the shoe has worn away at this point, the bearing will principally be at the top of the shoe, at b. In either case the reel is forced against the shaft with an undue pressure which is liable to cause abrasion of the reel-bushing. Besides, a large brake drum is liable to get somewhat out of round, on account of the expansion by heat produced by friction. In such a case a severe pressure will be borne by the reel-bushing if the brake-beams are not hinged in a somewhat yielding manner, often severe enough to cause the destruction of the brake-beam itself. Without doubt, the most correct and reliable way is to support the brake-beams by links as shown in Fig. 3, in which case any undue wear of the reel-bushing and uncalled for strain in the beams themselves are avoided.

The holding power of the post-brake can easily be estimated for a given weight W in pounds, setting the brake, if we know the coefficient of friction between brake-shoes and drum. Referring to Fig. 3, the normal pressure between each brake-beam and the drum is

$$N = \frac{1}{2} \frac{n}{m} \frac{l}{a} W$$

and from this expression we get

$$L R < f r \frac{n}{m} \frac{l}{a} W, \text{ or} \qquad (14)$$

$$W > \frac{L R a m}{f r n l} \qquad (15)$$

where f = coefficient of friction between the shoe and drum. This coefficient varies somewhat for different materials used in the brake-shoe. When basswood or cottonwood shoes are used, a proper value would be $f = 0.25$.

L = maximum unbalanced load in pounds.

R = radius of the rope-drum.

r = radius of the brake-drum. This radius is generally made as large as convenient. For flat rope reels it is equal to the outside radius of the reel; for cylindrical drums it equals the radius of the rope drum, and for conical drums it often is equal to the radius of the smaller end of the cone.

The holding power of brake-bands is computed by the formula

$$L R = P r (e^{fa} - 1) \qquad (16)$$

and the force with which the band should be tightened in order to hold the load

$$P = \frac{L R}{r (e^{fa} - 1)} \qquad (17)$$

where P = the force with which the free end of the band is pulled,

$e = 2.71828$, the base of the Naperian system of logarithms,

f = coefficient of friction,

a = the part of the circumference 2π around which the band is wound; for instance, if the brake-band is wound $\frac{2}{3}$ around the full circumference then $a = \frac{2}{3} 2\pi = 4.19$.

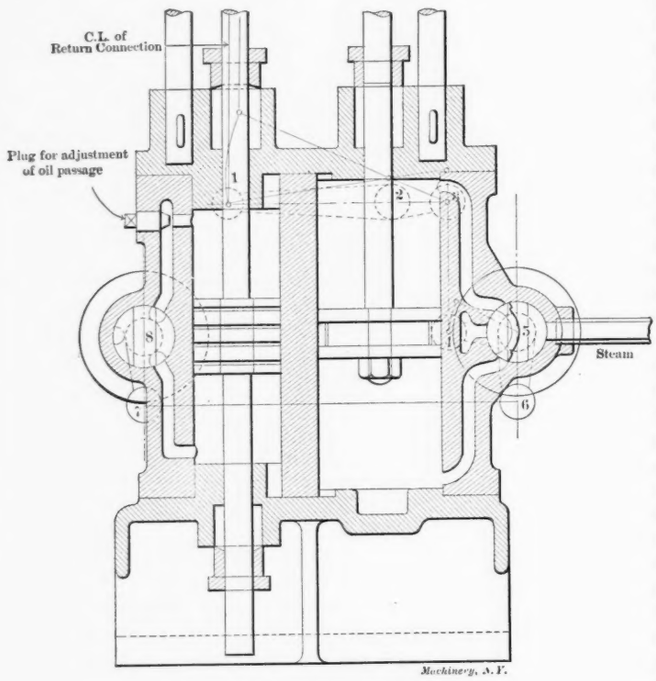

Fig. 5. Cylinders of Steam Reversing Engine.

The following table will be found convenient when solving questions relating to this subject:

f	$\frac{a}{2\pi} = 0.3$	0.4	0.5	0.6	0 7	0.8	0.9
0.18	$e^{fa} = 1.40$	1.57	1.76	1.97	2.21	2.47	2 77
0.25	$e^{fa} = 1.60$	1.87	2.19	2.57	3.00	3.51	4.11
0.40	$e^{fa} = 2.13$	2.73	3.51	4.52	5.81	7.47	9.60

The question of the strength of the brake band is very simple. The principal condition is that the tensile strength of the anchored end of the band should be ample to hold the load with a large factor of safety, to allow for vibrations which sometimes are quite severe, thus:

$$A = \frac{R}{r} \frac{F}{s} L$$

where A = the sectional area of the band in square inches.

S = tensile strength of the material.

F = factor of safety,

and R and r = the radii of the rope drum and brake drum.

The band is generally made of steel of about 60,000 pounds tensile strength; $\frac{S}{F}$ should therefore be taken at 6,000 to 8,000 pounds.

Both band- and post-brakes are generally operated on the gravity principle for the larger engines where steam power is used to set the brake. The advantage of this arrangement is that, in case the steam pressure should accidentally be shut off from the cylinder, the brake weight would still keep the brake set.

In designing a brake engine cylinder the stroke should not be made too short, for by a longer travel and therefore closer control of the brake piston a more graduated brake pressure can be obtained, with consequent better results when lowering the cage with the brake.

The brake engine is generally provided with an oil cylinder for giving a steady motion to the piston. This oil cylinder is sometimes fitted with an automatic controlling valve like that of the reverse engine; sometimes only a plug valve for adjustment of the oil passage is provided. This latter arrangement is quite satisfactory where the duty of the brake is only to hold the load, but where lowering of timber is done with the brakes, an automatically-controlled oil valve is much to be preferred.

Steam Reversing Gear.

A section through the cylinders of a steam reversing engine is shown in Fig. 5. This construction is suitable for being connected directly to the reverse lever; various arrangements are, however, found in practice. The reverse engine is generally provided with a floating lever arrangement, as shown in dotted lines at 1, 2 and 3, Fig. 5. Several positions of the floating lever with the resulting valve movements are shown by diagram in Fig. 6. The purpose of the floating lever arrangement is to so control the piston that it will always take a position which corresponds with that of the operating hand lever; for instance, if the hand lever is thrown full over, the piston will move to the corresponding end of its stroke, and closing the steam and oil valves when arriving at this position, will be locked there until the hand lever is thrown to a new position.

Referring to Fig. 6, the right-hand part of the figure shows the movement of the reverse arm by which the position of the link is reversed through the action of the hand lever. This figure is really the upper part of Fig. 5, the piston rods and uprights being shown broken in each figure. In the operation of the floating lever, which is directly back of the cylinders in Fig. 5, the point 2 is connected to the hand lever, point 3 to the steam and oil valves by the bell cranks and linkages shown, and point 1 is joined to the oil cylinder connecting rod as shown, by what is called the return connection. Point 2 is now, for example, raised by means of the hand lever when point 1, being anchored to the comparatively heavy reciprocating parts, acts as fulcrum, and point 3 is accordingly raised as shown in diagram 2, opening the steam valve and the oil by-pass valve, admittting steam below the piston, and allowing oil to pass from the upper side of the oil piston to the lower side. The piston accordingly rises, and, point 2 now acting as fulcrum, point 1 will be raised by the return connection, and point 3 returned to its original position, as shown in diagram 3, Fig. 6, thus closing the valves. The object of the oil cylinder is simply to prevent shock, as the oil slowly passes from the forward to the

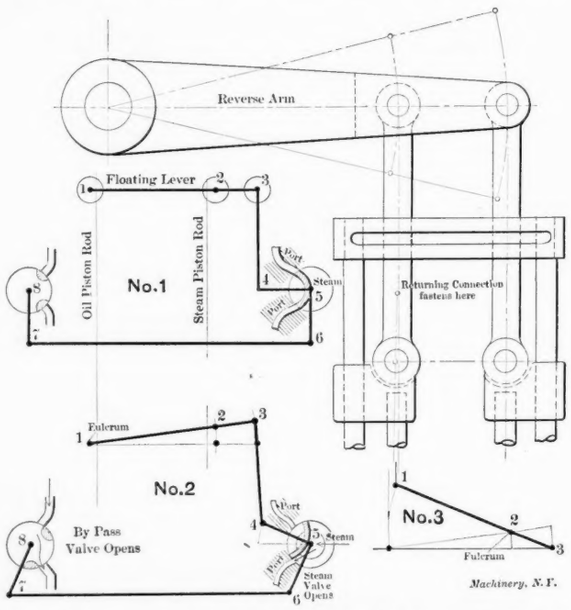

Fig. 6. Diagram illustrating the Floating Lever Mechanism of Valve Gear.

back side of the oil piston, past the regulating plug and through the by-pass valve. For the next reversal of the link point 2 would be lowered, when the steam port above the piston would be opened for the passage of steam and the piston lowered.

The size of the brake-engine cylinder is proportioned so as to lift with ample margin for certainty the heaviest brake

weight which, according to equation 15, is required to set the brake. The different leverages on which the engine cylinder and the brake weight act should of course be taken into consideration. When the brake is set, the steam is sometimes admitted on top of the brake engine piston, thus making the holding power of the brake doubly certain. However, the weight should in each case be amply heavy to hold the load when acting alone.

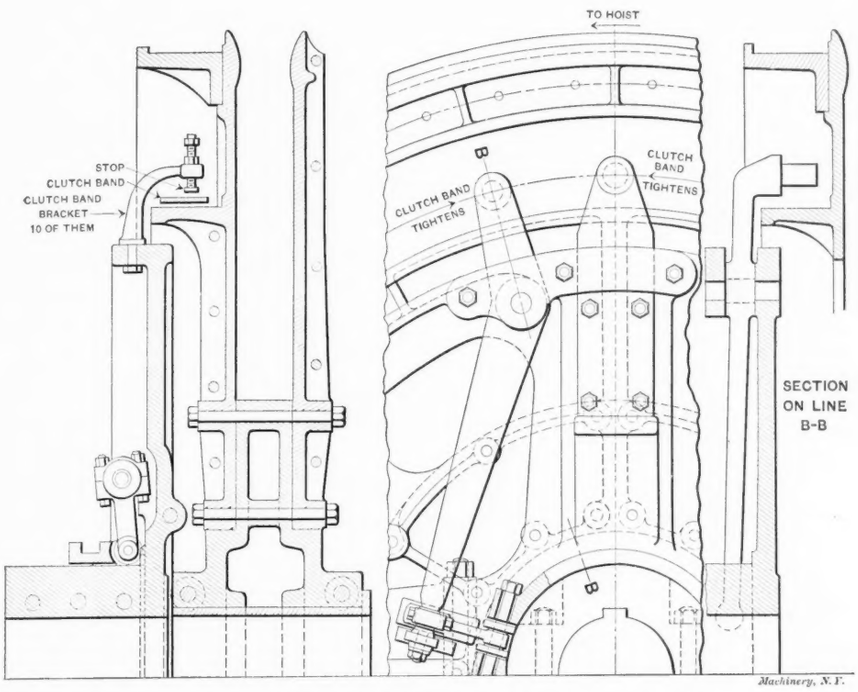

Fig. 7. Details of Band Clutch Wheel.

Clutches.

In connection with double-drum hoists the two hoisting drums are often required to be independent of each other, so that the cages can be operated in balance, or separately as desired. This feature is particularly advantageous when lowering timber to the different levels of a mine.

Various forms of clutches are employed for connecting and disconnecting the drums from the driving gear. Tooth clutches are quite satisfactory for smaller drums, although somewhat slow to operate. For large engines the band clutches are, however, nearly exclusively used. These can be easily proportioned by following the formula given for the holding power of band-brakes.

Fig. 7 gives various sections through a band-clutch wheel, showing the arrangement of levers for the operation of the clutch. In the left-hand figure is shown one of the stops, back of the band, against which centrifugal force throws the band when revolving free. The movable end of the band is attached to the pin in the end of the lever, pivoted on the clutch wheel, which is solidly keyed to the driving shaft. The other end of the band is held by a pin rigidly connected to the clutch wheel, so that by swinging the movable end of the band toward the fixed one the band is tightened, gripping the clutch ring cast together with the rope reel. In large hoists the clutch is often operated by a separate clutch engine.

Miniature.

The miniature, or indicator, as the device is called, which shows the operator the position of the cage at all times, consists, essentially, of a hand moving over a dial on which the different stations are marked. The hand is geared, from the main shaft, in such a way that a certain number of turns of the drum, corresponding to the unwinding of, say, one hundred feet of rope, give to the hand a motion of a corrresponding arc on the dial. A second hand moving on the same dial is sometimes provided. This hand makes one full revolution while the cage is moving the distance between the first station below the surface and the surface landing.

Since the main hand is positively geared from the drum shaft, it moves over equal arcs on the dial for equal numbers of turns of the drum. One difficulty arises on this account in connection with conical drums or band-reels, where the hoisting band is wound upon itself when hoisting. In these cases it may be that twice the number of turns of the drum is taken for hoisting one hundred feet when the cage is at the bottom levels that is taken when the cage is near the surface. Therefore the distances between the station marks on the indicator dial will be of correspondingly unequal lengths. To correct this feature, the indicator has in some cases been provided with specially-constructed gears which give to the indicator hand a fast and a slow motion, neutralizing the fast and slow motion derived from the drum-shaft. This feature complicates things somewhat and would not be desirable except in special cases in connection with deep hoisting. Fig. 8 is chosen as an example showing all these refinements. In this figure the primary hand, pointing down, is solidly connected with the drum shaft through the hollow sleeve, snake wheel and pinion, vertical shaft, and two sets of miter gears not shown. This motion, therefore, follows the rope drum, and shows correctly the location of the cage at all times. The arm *A*, secured to the hollow sleeve, follows the motion of the primary hand, so that when the latter arrives at the station marked 1, the arm *A* comes in contact with the tongue *B* and rotates this about its pivot. On the shaft to which *B* is secured is also secured the sector gear and weight *W*, the sector being in mesh with the pinion *P*. Arm *A* keeps in contact with tongue *B* during the progress of the primary hand from station 1 to the surface, during which time pinion *P* makes on complete revolution. As pinion *P* is on the central spindle *S*, which passes through the hollow shaft before mentioned and the second hand, pointing up, is also on this spindle, the latter is moved one turn around

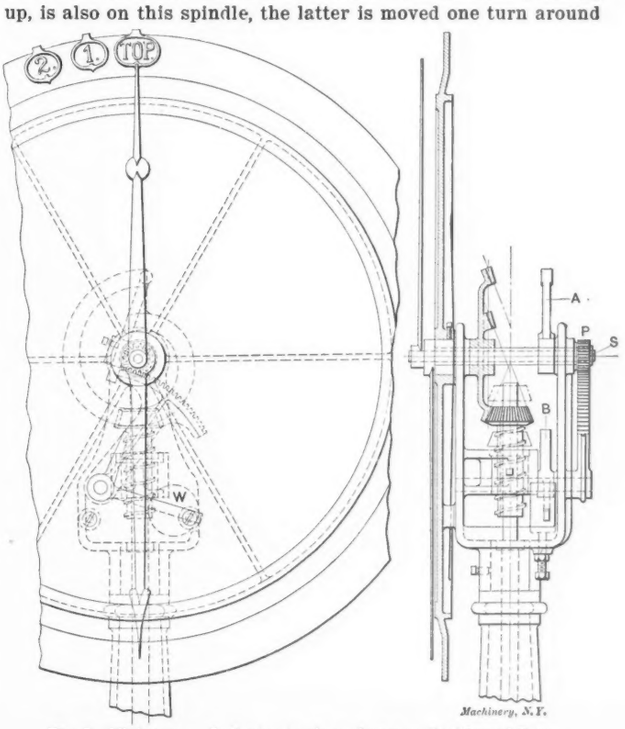

Fig. 8. Miniature or Indicator to show Operator Position of Cage.

the dial by the action of the sector and pinion, thus locating more closely the position of the cage while it is progressing from the first station to the surface, than would the primary hand in moving the short distance from mark 1 to the top of the dial. When the cage is again lowered down the shaft, the weight *W* returns the tongue *B*, the sector, and the second hand to their initial positions. The refinements shown in this construction are not as a rule necessary in ordinary practice.

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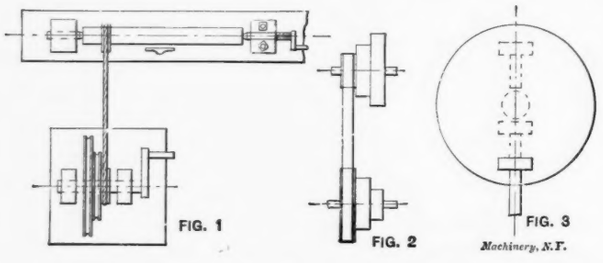
VARIABLE SPEED MECHANISMS.—1.

THEIR DEVELOPMENT AND GENERAL PRINCIPLES.

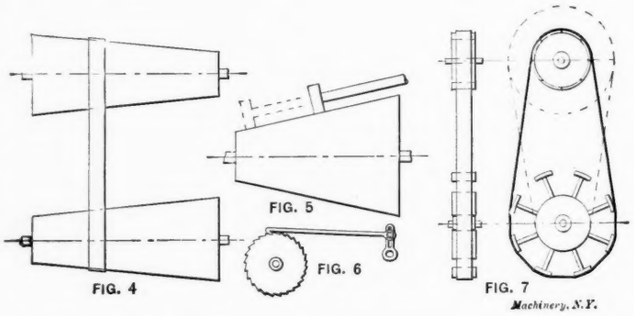
Almost from the time that machines were first invented the need has been felt for some means of varying the velocity ratio of the driven or work spindle to the source of power. It is true that this was not a serious want at first, for the primitive machines being driven by hand or foot power could be speeded at the will of the workman (within narrow limits), but, strangely enough, what is probably one of the first machines ever used by mankind contained a variable speed feature. It is generally believed that the potter's wheel, a form of the lathe, was the first machine because of its intimate relation to



working clay, the first material largely used in the constructive arts. It consisted of a circular table supported on a vertical axle, and near the base of the axle was attached another disk or wheel by which the work table was propelled with the foot. Now, since the sizes of pots and other circular vessels vary in diameter, it follows, of course, that the smaller ones should be formed at a higher rate of rotation than the larger ones in order to get the proper peripheral speed necessary for shaping the wet clay. The workman could vary the speed by moving his foot faster, but there is a natural rate of action which a man must follow in order to work continuously without excessive fatigue. In propelling the potter's wheel he could maintain about an even stride, no matter what the diameter of the work, by merely shifting the position of his foot relatively to the axle. When shaping a small pot, if he struck the wheel nearer the axis of rotation it would increase the speed with practically no change in the physical exertion required and *vice versa*. Hence we see that the first and primitive machine contained an ideal variable speed mechanism for that period, which, however, can scarcely be said to exist to-day in spite of our boasted progress and mechanical skill.

In the natural course of evolution it was but a step from the potter's wheel with vertical axis to the horizontal lathe with stationary poppets for turning forms of wood and iron. The work in this case takes the place of the axle. Although the lathe did not at first have a rotating spindle, and was therefore in some respects a still more primitive machine than the potter's wheel, in the pole-lathe it did contain the feature of constant speed at the surface of the work. This, of course, is equivalent to a variable speed work spindle, since the first object of the variable speed device in a lathe is to maintain a fixed rate of cutting speed irrespective of the diameter of the piece being turned. Now the pole-lathe consisted of two poppets supported on a wooden bed, and suspended from the ceiling was a wooden spring-pole, to the free end of which was attached a strong cord. This cord was wound once around the piece to be turned, and the loose end was carried down to the floor where it was formed into a loop for the workman's foot. In improved forms of the pole-lathe a rude treadle was provided instead of the loop. When the foot was depressed, the work piece was turned by the cord against the cutting tool, the spring-pole of course depressing at the same time. With the upward lift of the foot the spring-pole raised the cord and turned the work in the opposite direction. The point to be noticed is that no matter what the diameter of the work piece, it would rotate against the cutting tool with approximately the same working speed—the ideal condition when working various diameters in metal of the same characteristics, and the one for which we are yet striving. With the treadle the workman could also vary the working speed if he so desired by shifting the position of the foot on the treadle, thus making the work turn faster or slower with an even motion of the foot.

The pole-lathe, however, had the serious objection that the work did not turn continuously, but was turned alternately in opposite directions. A very high degree of skill was required to do satisfactory work, as the turning tool had to be lifted the moment the work began to turn backwards, and had again to be brought to cutting position when the reverse movement began. Hence the application of a driving wheel connected by a cord to drive the work continuously in one direction. The driving wheel, which was turned by a crank, was mounted on a separate stand or base placed to one side of the lathe and was usually provided with three grooves. See Fig. 1. The cord was carried directly by the work, if of ordinary size, and if smaller a pulley was sometimes mounted upon it in order to give it the necessary turning moment. The first record that we have of this combination, according to J. J. Holzpffel in his interesting work "Turning and Mechanical Manipulation," appeared in the "Manuel du Tourneure," published in 1816, but doubtless this principle of varying speed had been used many years before, for in Shopper's work, 1568, is shown an illustration of the wheel driving the work of a lathe, and doubtless the possibilities of changing the speed by a number of grooves of varying size must have been understood at this date. In this early machine, the driving cord also ran directly on the work, or if it was too small a pulley was mounted on the work piece, and the cord run on the pulley. This expedient was resorted to in order to prevent slipping of the cord, but it made necessary some means for compensating for loss of cutting speed, hence a number of grooves in the driving wheel. This type of machine, of course, required two workmen, one to turn the crank and the other to handle the cutting tool. Hence the preference for the foot-power lathe, having the driving wheel beneath the lathe shears, and with the advent of the rotating spindle in the early part of the nineteenth century came the combination



of the driving wheel with a number of grooves and a pulley mounted on the spindle having an equal number of grooves for the cord. In this we have the familiar cone pulleys, Fig. 2, now generally employed for changing speed.

While the cone pulley is an effective means of varying speed ratios, it requires a momentary cessation of the work for changing it from one step to the other. This is found objectionable, not only because of the time lost, but also, in the case of lathe work, because of the marking of the work where an abrupt change of speed takes place. Again, in many machines it is desirable that the changes or grades of speed merge imperceptibly, or that the change from one rate to another take place without the necessity of human intervention, the change being effected by the machine itself or some outside influence as occasion may require. For light powers the disk wheel and friction roller, Fig. 3, the principle in effect first employed in the potter's wheel, has been used and is still used in a great variety of forms as we shall see. The disk and friction wheel

also has a useful characteristic of reversing the direction of rotation by traversing the friction wheel across the center of the disk. The smooth cone pulleys, Fig. 4, have been used very largely in textile machinery, where it is necessary to gradually vary the speed, and where it was desirable that the change be effected automatically. A combination of the principle of the disk wheel and the cone pulley is that of Fig. 5, the plate being replaced by a friction disk. The change in velocity ratio is, of course, only one-half as great with this arrangement as it would be with two cone pulleys of equal taper connected by a belt. Although the cone pulley is doubtless a very early invention, it appears to have been patented in England in 1841 by J. D. Bodmer, and was used by him in his remarkable improvements of machine tools in ratios of 9 to 1, and sometimes as high as 18 to 1. The ratchet device of Fig. 6, in one form or another appeared early in machine tool design, and has been used almost entirely for varying rates of feed, but as we shall see later, this principle has also in later years been applied in variable speed devices for varying the rate of driving the machine. In Fig. 7 we have the expanding pulley, a difficult mechanism to properly design, but one that has been used with moderate success in many forms of patented speed-varying mechanisms, as will be shown in the review of the principal United States patents to follow.

In connection with the stepped cone pulley we must not neglect the familiar back gear of the lathe, Fig. 8, which when properly designed, doubles the range of speed variation and changes the effective turning moment of the work in direct proportion to the change of speed. This device was doubtless an early expedient of iron workers to increase the effective working power of the foot-power lathe. It obviously came into use after the development of the rotating spindle. The triple back gear is but an extension of this principle, found

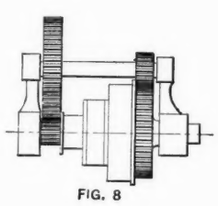


FIG. 8

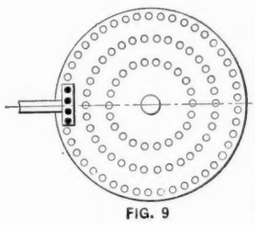


FIG. 9

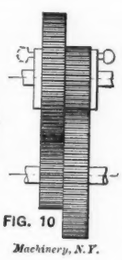


FIG. 10

Machinery, N.Y.

necessary as larger and more powerful lathes were built. A variation in the back gear construction, doubtless of early use, is that indicated in Fig. 10. Two gears are mounted firmly on a shaft but the opposing gears are loosely mounted on another shaft. On each side of these gears is mounted a flange firmly keyed to the shaft. To make either gear drive a loose pin is inserted through the flange on that side into the gear, thus making the flange and gear turn as one.

In Fig. 9 we again have in effect the old disk and friction wheel with the friction feature left out. As many concentric rows of round pins are provided on the disk as there are speed changes wanted, three being shown in this case. The small wheel or pinion has holes to match the pin teeth. This primitive arrangement has been used in many forms and with good success with comparatively light work. An improved form makes the pins modified bevel teeth and teeth of corresponding shape are provided in the pinion. With narrow faces it is possible to change this arrangement from one speed to the next by shifting the pinon shaft longitudinally without lifting out of mesh as is necessary with the primitive construction.

In all the foregoing types chosen to illustrate principles, we find that to effect any change in velocity ratio, it is necessary to change the radial length of one or both the rotating members connected. Thus in the disk and friction wheel the radial length of the working part of the disk is changed with the shifting of the friction wheel across its face; in the taper cone pulleys the working radial lengths of both the driving and driven member change with the shifting of the belt, and so on throughout the list. But this principle is not universal for it is possible to change the relative rate of rotation by other expedients, as for instance, the hydraulic pump and motor, one or both of which have means for varying the capacity per revolution. If the capacities are the same the rate of rotation will necessarily be the same, but any change one way or the other in either the pump or the motor will change the velocity ratio. It is also possible to change velocity ratio in pure mechanism as for instance in the diagonal rack and pinion illustrated by Prof. MacCord in his Kinematics, or by employing the principle of the guide-bar of a lathe, the inclination of which determines the transverse rate of a rack meshing with a pinion and consequently the rate of rotation of the latter relative to the rate of longitudinal transition. Both these devices can be used for limited movements only, and, therefore, are useless for continuous rotary motion in one direction. Reviewing the foregoing we find that the velocity ratio of rotating members may be changed in the following ways:

1. By changing the relative radial lengths of the surfaces in working contact, as in the disk and friction wheel.
2. By changing the point of application of the belt connecting cone pulleys, either of the stepped or taper form.
3. By changing the throw of ratchet mechanism.
4. By the use of expanding pulleys.
5. With the crown gear having multiple sets of concentric teeth.
6. By the use of the back gear either in connection with cone pulleys or without.
7. With cones of gears, with means for locking one and tightening another. An alternative plan is the use of an intermediate gear provided with means for bringing any two pairs of opposing gears into connection.

* * *

OIL GROOVES AND THE FITTING UP OF BEARINGS.

C. H. BIERBAUM.

The grooves in bearings may be divided into two classes; first, the oil grooves proper, whose function is that of distributing the oil lengthwise in the bearing, and to supply the oil directly for the formation of the film, which are properly called "oil grooves"; secondly, the grooves whose function is that of feeding the oil from the supply to the oil grooves proper; these are "feeders" and are correctly named as such.

The oil grooves should always be parallel with the journal in order to effect a uniform distribution of the oil and the formation of an even and unbroken film; the feeders, if cut in the bearing surface should always be cut at right angles to the journal. Oil grooves should never be cut spirally or obliquely. If the oil does not feed into the bearing properly the cause for the same should be determined. It is quite true that spirally-cut oil grooves produce a relatively free flow of oil through the bearings and this has led to a somewhat general misapprehension as to their value. A large or sufficient quantity of oil flowing through a bearing does not indicate that the bearing is being properly lubricated, for the only condition under which oil in a bearing serves its purpose is when it exists in the form of a film between the bearing surfaces, keeping them separated, and offering a fluid friction surface instead of allowing metallic contact. The natural tendency for the oil after it is first brought in contact with the journal or bearing is to form a film over its entire surface and to adhere to it tenaciously. One of the causes for the destruction of this film of oil is an excessive pressure per unit of area. This may be due to a defective design, in that an insufficient bearing surface has been allowed, or it may be due to improperly fitted surfaces producing excessive pressure on "high spots." Whichever the cause may be, under these conditions, no improvement can be made by cutting away necessary bearing surface for an increased capacity of oil grooves. Another cause for the destruction of the oil film is that of a sharp scraping edge in contact with the journal, and when this scraping edge makes an oblique or spiral contact with the journal, its destructive effect upon the oil film is all the more severe.

In a reciprocating bearing, or one in which the thrust is exerted in alternately opposite directions, the oil film should be restored on one side of the bearing while the pressure is being exerted upon the other. For this reason the location of the oil groove should be fully considered, in order to best effect this lubrication. The edges of the half-bearings should

bear firmly against each other so that, owing to the elasticity of the bearing and the compression of the oil film on the side of the bearing receiving the thrust, the other side of the bearing may be sufficiently relieved from the journal to permit a complete restoration of the film. In a bearing in which the thrust is constantly and uniformly exerted in one direction, the lubrication is dependent upon the film of oil adhering to the journal by capillary affinity and on being carried around with the same. Other conditions being the same, the pressure per unit of area of this bearing surface must, therefore, be less than that permissible in reciprocating bearings.

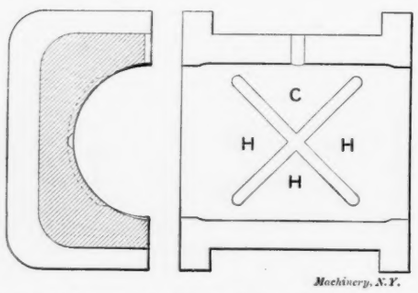


Fig. 1. The Common but Wrong Arrangement of Oil Grooves.

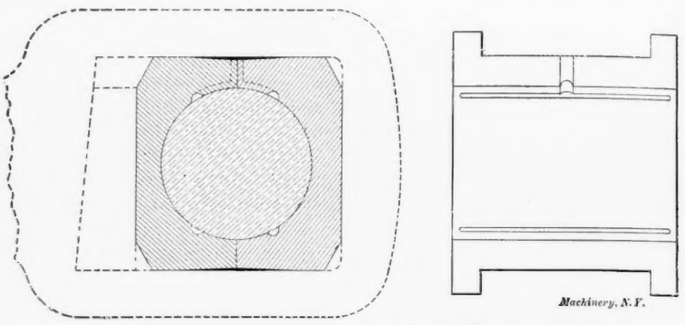


Fig. 2. Correct Arrangement for Bearings of a Horizontal Connecting Rod.

Oils differ as to amount of capillary affinity they have for metallic surfaces, and naturally, the greater this affinity the more persistent will be this film of oil.

Oil grooves, in a measure, may be considered as a necessary evil, whose function is to supply the oil for the film; but after that is done and a perfect film is produced, the conditions would then be improved if no oil grooves existed into which this film could be squeezed. The larger the area of oil film free from grooves or cavities, the greater pressure per unit of area can this film resist without being squeezed out. The idea, therefore, is to locate the oil grooves so as to make them effective in restoring the film at each revolution, and at the same time not have them appear in that part of the bearing surface receiving the maximum thrust.

Fig. 1 represents the old-fashioned bearing with its chamfer and cross oil grooves, assuming the direction of rubbing surfaces from *C* to *H*. This construction cannot be criticised too severely. Three of these areas marked *H* contained within the angles of the intersecting grooves, are poorly lubricated, leaving one area, marked *C*, as the only properly lubricated one. Experiments show that if a thermometer bulb is brought in immediate contact with the bearing surface at different points, the area indicated by *C* would be cool as compared with those marked *H*. The latter show heating due to imperfect lubrication. This is the case with every area of bearing surface lying immediately beyond an oblique groove, and for this reason they should always be avoided.

Fig. 2 represents a crankpin or crosshead bearing for a horizontal connecting rod properly grooved and fitted. The two oil grooves above and the two below the pin are placed symmetrically in the half-bearings, a distance apart equal to one-half the diameter of the pin. The two upper grooves in both half-bearings are connected by feeders, fed directly from the oil cup. Each bearing should be relieved on its upper and lower sides in a manner shown by the upper and lower heavy line. The corners of the half-bearings should be cut away to the extent shown, leaving an area equal to the projection of the crankpin. This construction allows the bearings to become heated and expand appreciably without producing a binding action upon the crankpin.

Fig. 3 represents a crank bearing lubricated through the center of the pin. The two oil grooves in the crankpin should be placed diameterically opposite each other so that their plane makes an angle of 45 degrees with the plane of the crank and shaft. The angle of the two planes should be rotated 90 degrees, if the direction of rotation is opposite from that shown by the arrow in the illustration. In this bearing the same as in Fig. 2 the corners should be cut away and the bearings should be relieved on their sides. For a crosshead pin bearing oiled through the center of the pin the same system of oil grooves as shown in Fig. 2 should be used. The hole drilled through the crosshead pin should be at right angles to the piston rod instead of at 45 degrees, as shown in Fig. 3.

Fig. 4 represents a crankpin bearing for a vertical connecting rod. The same general principle of oil grooving as in the preceding two figures is adhered to, in that 85 per cent of the projected area of bearing surface, in the center of the bearing, is free from grooves, and at the same time offering ample facilities for lubrication. The details of the feeders may vary considerably, depending upon the special construction and design of the other parts; but the principle of avoiding the placing of oil grooves in the line of maximum thrust should always be considered in fitting up bearings.

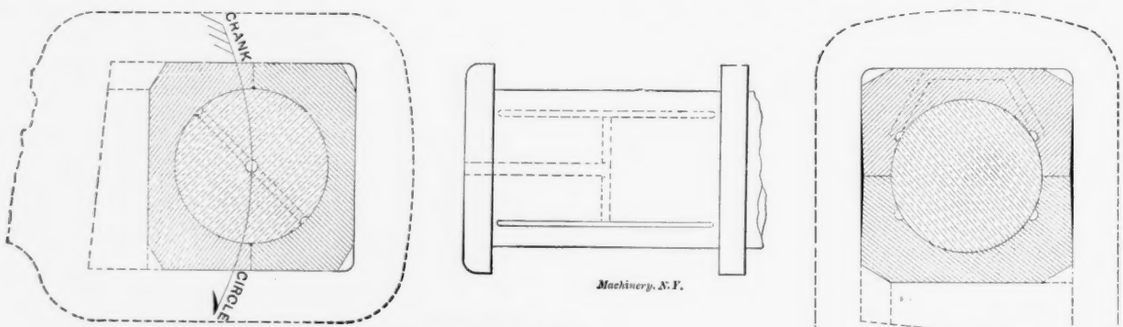


Fig. 3. Showing Distribution of Oil from Center of Crank Pin.

Fig. 4. Crank-pin Bearing with Oil Grooves for a Vertical Rod.

It is sometimes found desirable to vent the oil grooves at the ends of the bearings by drilling holes through the bearing. This produces a freer flow of oil, thus doing away with air cushioning, but spiral or oblique oil grooves for this purpose should never be resorted to.

* * *

The first large war vessel to be equipped with turbine engines, we believe, is the cruiser *Amethyst* of the British Navy. This vessel, which was recently completed, developed a speed of 23½ knots over a measured course on the Tyne. Her gun equipment consists of twelve 4-inch and eight 3-pounder rapid firers; the cost of the vessel is about $1,150,000.

NEW WORKS OF THE INGERSOLL-SERGEANT DRILL CO.

A LARGE PLANT, COMPLETE FROM OFFICE BUILDING TO FOUNDRY, WITH MANY FEATURES OF INTEREST.

The Ingersoll-Sergeant Drill Co. have nearly completed extensive new works at Phillipsburg, N. J., for the manufacture of air compressors, rock drills, and other compressed air apparatus. The business of this company has grown so rapidly and now includes so great a variety of machinery, that the works at Easton, Pa., where their manufacturing has been carried on, have been outgrown, and some two years ago work was commenced on a new plant at Phillipsburg, N. J., which is situated across the Delaware river from Easton.

Fig. 1. Exterior of Foundry from the Elevated Land at rear of Foundry.

The site of the old plant is on a bank of the Lehigh River at Easton, and although it is a large tract it is now so covered by the buildings of the plant as to afford no opportunity for future growth. While most of the buildings are comparatively modern, it was thought best to arrange for complete abandonment of the plant, should this seem advisable in the future, by erecting new works, complete in every respect, from office building to foundry, on a location where there would be ample opportunity for future development. The manufacture of rock drills, which forms an important part of the business and was the original business of the company, is now carried on at the new works. The more important part of the air compressor work is now being transferred to the new plant as rapidly as possible. For the present the smaller air compressors will still be manufactured at Easton, as well as the pneumatic tools, although there may be provision for the manufacture of both at the Phillipsburg works at a later time.

The layout of the new plant and the design of the buildings are the result of a great deal of investigation and study with the view of adapting them to the wide variety of products manu-

Fig. 2. Interior of New Foundry of Ingersoll-Sergeant Drill Co.

factured and also to meet the difficult problem of future growth without disturbing the orderly sequence of the work passing through the factory. In designing the plant, also, there were a number of engineering problems of considerable magnitude to be met, owing in part to location and in part to the great area covered by the buildings, and these have been solved in a novel and original manner, adding much to the interest of the plant from an engineering standpoint.

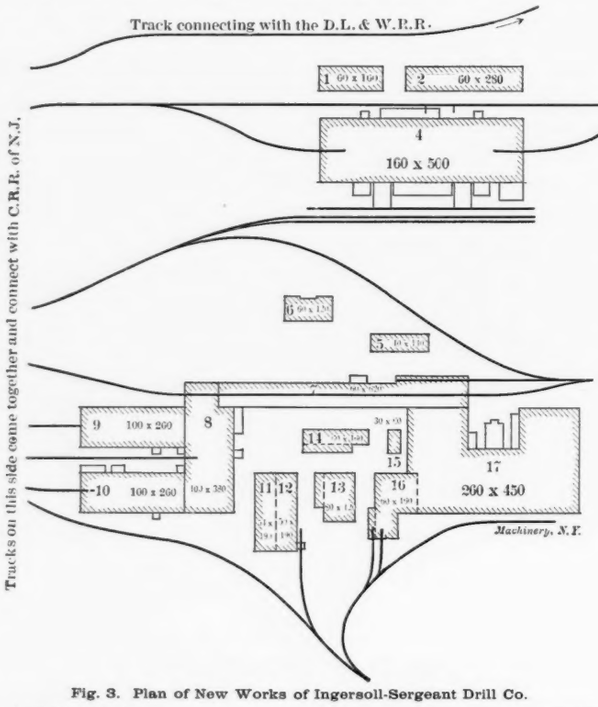


Fig. 3. Plan of New Works of Ingersoll-Sergeant Drill Co.

1. Pattern Shop.
2. Pattern Storage Building.
3. Casting Cleaning Building.
4. Foundry.
5. Carpenter Shop.
6. Office Building.
7. Warehouse and Shipping Department.
8. Air Compressor Erecting Shop.
9 and 10. Compressor Machine Shops.
11 and 12 Power Plant.
13. Blacksmith Shop.
14. Steel Treating Department.
15. Rock Drill Testing Department.
16. Receiving Department.
17. Rock Drill Manufacturing Shop.

will soon be completed. Its other advantages were so great that it was thought best to incur the expense necessary to provide a water supply and a subsidiary company, called the Lopatcong Water Co., was formed for the purpose. A dam 2,000 feet long was built across a river basin some 4½ miles away, forming a storage reservoir over 350 feet above the level of the works. The water flows by gravity to another reservoir at a less elevation, but sufficient to give a pressure of 100 pounds per square inch at the works. The total storage capacity of the two reservoirs is 33,000,000 gallons.

In Fig. 3 is a plan of the works, with a list of the buildings, and in Fig. 6 a perspective view. In the foreground are the foundry, pattern shop and pattern storage buildings, indicated respectively by numbers 4, 1 and 2 at the top of the plan view. Directly back of the foundry and on higher ground, is the office building, No. 6, and back of that the large group of buildings, arranged around three sides of a hollow square, where the machine work is done. On one side of the square are three buildings, 8, 9 and 10, for the manufacture of air compressors. Building 8 is the highest of the group and is the compressor erecting shop, while buildings 9 and 10, connecting with it are the compressor machine shops. It will be observed that buildings 8, 9 and 10 can be indefinitely extended, or if preferred several structures similar to 9 and 10 could be added, should the erecting shop, No. 8, be lengthened.

On the opposite side of the square is an immense one-story shop, with saw-tooth roof, where the rock drills are manufactured. It is generally admitted that this style of shop has no superior for medium and light work, and we have here in contrast, on the two sides of the square, two structures of entirely different design, but each adapted to the class of work for which it is intended. The practice of designing the different parts of a plant to accommodate the work, instead of trying to adapt the work to the plant, is coming to be a prevailing one, and there is here one of the best illustrations of this advanced idea to be found anywhere.

The third side of the square is occupied by a long warehouse, where the finished machines are stored and from which they are shipped. The warehouse can be extended at either end and it will be noted that the rock-drill shop can be added to in any of three directions..

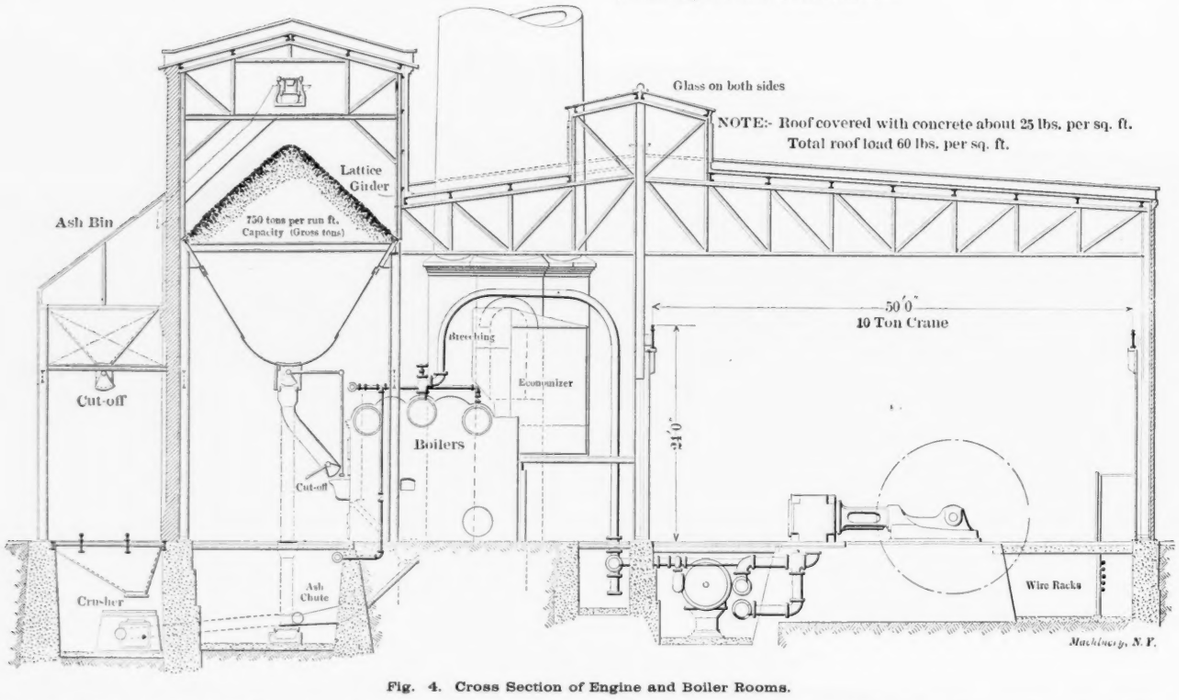


Fig. 4. Cross Section of Engine and Boiler Rooms.

Not the least of these problems was that of water supply. The site of the new plant is an ideal one except for the lack of a natural water supply. The tract of land is a plateau of 200 acres, so situated that two railroad connections are easily secured, and trolley connections with Phillipsburg and Easton

In the center of the main group are several buildings, the larger one of which is the power plant, marked 11 and 12. No. 13 is the blacksmith shop, No. 14 the steel treating department, and No. 15 a building where rock drills are tested before shipping. The power plant, it should be noted, is cen-

trally located, and will remain so, whatever additions to the works may in future be made, and moreover the power-plant buildings, as well as the others in the hollow square, can be extended sufficiently, probably, to meet any requirements that may be made.

An important feature of the works is the track facilities for transferring material. There are over four miles of standard-gauge track in the yards and the company own their own locomotives and cars. There are, besides, narrow-gauge "industrial railways," for hand cars, connecting the different buildings or parts of buildings.

Referring now to the buildings more in detail, we have first what may be called the foundry group, consisting of the foundry, pattern shop, pattern storage and the casting cleaning building. This group is situated a few feet below the level of the other buildings of the plant, which is an advantage because of the facility with which the pig iron, coke, etc., can be carried to the charging floors for the four cupolas of the foundry.

In Fig. 7 is a cross-section of this group, and in Fig.. 8 a plan of the foundry. Starting at the right, in Fig. 7, we find a series of storage bins located under the brow of the hill. These bins are of concrete construction with concrete retaining walls. A track running across the top of the bins allows material to be dumped into any of them or to be deposited on top where it can be taken across one of the two bridges connecting this elevation with the charging floors. The foundry itself, an exterior and interior view of which is given in Figs. 1 and 2, is of steel construction, built with three bays, all served by traveling cranes. The central bay, where the heavier work is done, has the unusually wide span of 65 feet and a clear head room of 46 feet under the roof trusses. At the extreme left in Fig. 7 is indicated the location of the pattern shop and pattern storage building, with a yard between this building and the foundry served both by a standard gauge track and a traveling crane. This yard is a much appreciated part of the foundry arrangement. It affords flask storage and all the flasks are readily accessible because of the crane service. A view of the yard appears in Fig. 11.

The brass foundry is in a separate wing of the iron foundry, projecting from the main building and is fitted with Schwartz brass furnaces. In the iron foundry there are two 86-inch cupolas, one 78-inch and one 68-inch, provided with blast by motor driven blowers.

In cleaning castings, a sand blast is employed in connection with rattling instead of the pickling process, and as the sand blast makes a great deal of dirt and dust a separate building was built some distance from the foundry for this purpose. There are here two sand blast rooms where the larger work is cleaned and one or more of the rattlers for the smaller work are also fitted with a sand blast. An exhaust arrangement is used to draw the dust from this building and deposit it some distance away.

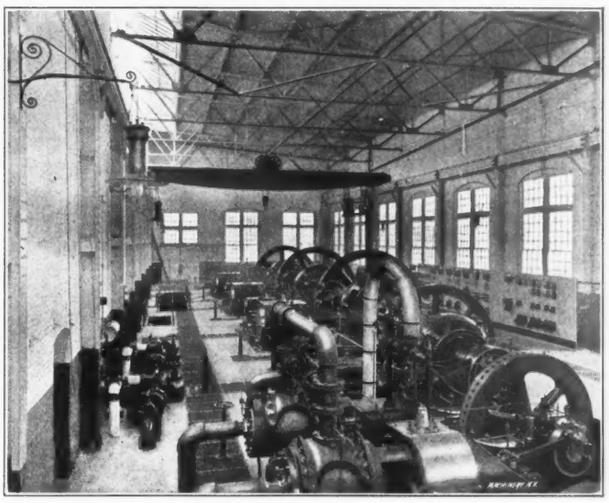


Fig. 5. Interior of Engine Room—Compressors in Foreground, Turbine Pumps at the Left

The excellent track facilities by which the different buildings of the plant are connected make it perfectly easy to transfer the castings to the cleaning building and then carry them around to the receiving department of the machine shop, (building No. 16), whereas if dependence had to be placed upon tram-cars operated by employees, this arrangement would not be so convenient.

The pattern storage building is of mill construction, three stories high, protected by automatic extinguishers. It is served by hydraulic elevator, running in a fire-proof well and the building is divided into seven sections by fire-proof walls which extend two feet above the roof. These features and others, such as self-closing doors, render the building prac-

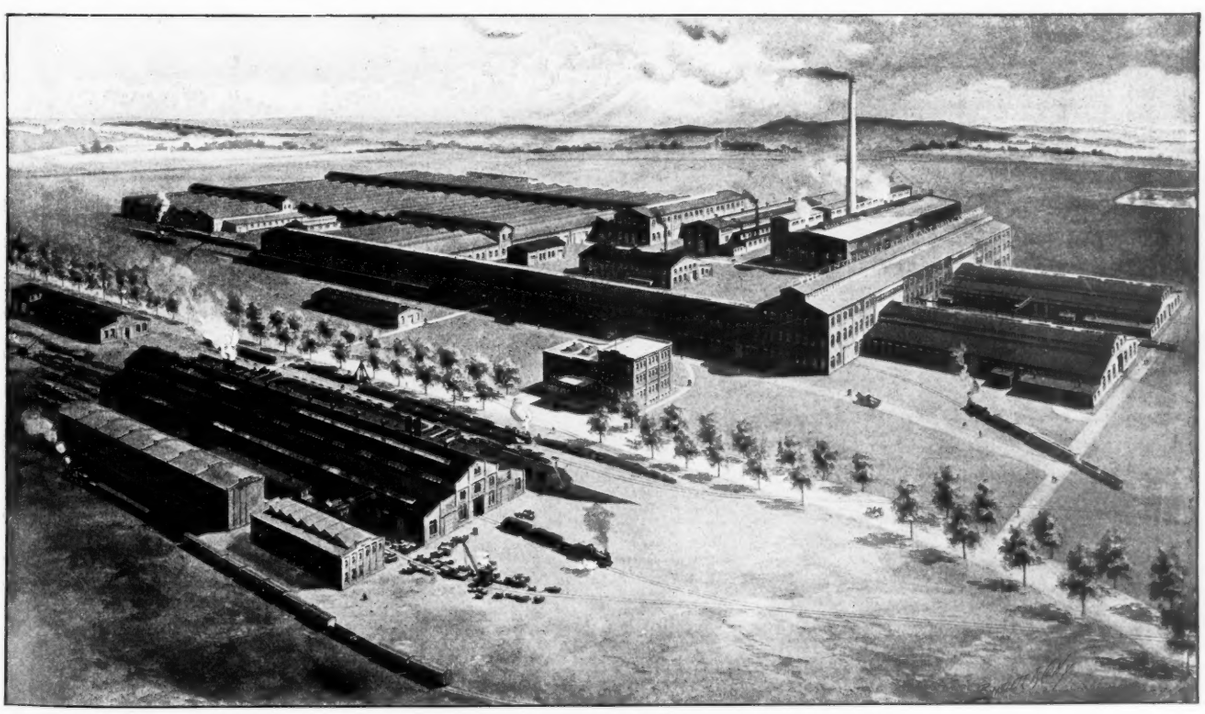


Fig. 6. The New Plant of the Ingersoll-Sergeant Drill Company at Phillipsburg, N. J.

tically fire-proof and assure, in any case, that the damage from fire would be very slight and confined to a small area.

The pattern shop is a two-story building lighted partly from the side and partly by saw-tooth roof.

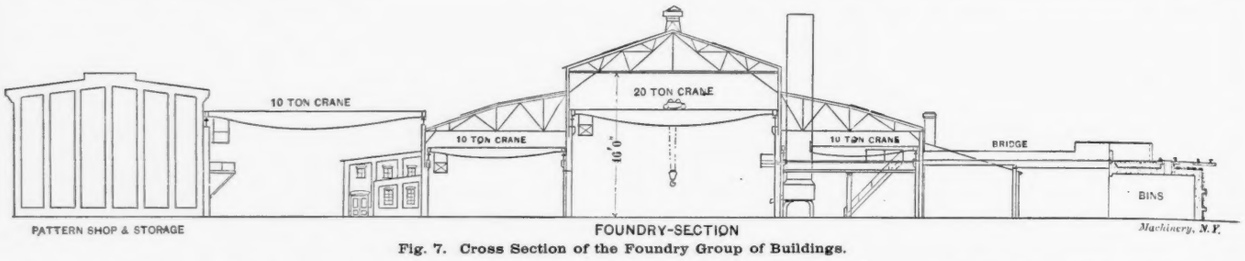


Fig. 7. Cross Section of the Foundry Group of Buildings.

As will be seen in Figs. 4 and 5, the power plant is of the usual modern type of construction, with parallel boiler and engine rooms, separated by a fire wall. The boiler installation consists of six Stirling water tube boilers, aggregating 1,500 horse power, fitted with Roney mechanical stokers. The boiler room is equipped with overhead storage bins, served by a conveyor, which is also used for carrying ashes from the pit below the boilers. In the engine room are four Cooper-Corliss cross-compound engines, direct-connected to Crocker-Wheeler generators, three of 300 K. W. capacity and one of 100 K. W. capacity. There are also two steam-driven Ingersoll-Sergeant air compressors installed, which supply air under two different pressures for distribution. In space reserved in the engine room there are foundations and pits for mounting steam-driven air compressors for duty tests, where they may readily be connected up to a condenser.

A feature of the power distribution is a tunnel extending from the power house to the different buildings, for carrying the power and lighting mains, the high and low pressure air mains, the pipes for the heating system, water pipes, etc. The tunnel is six feet square and its various branches aggregate a length of 2,200 feet. Its walls are of concrete and roof of reinforced concrete..

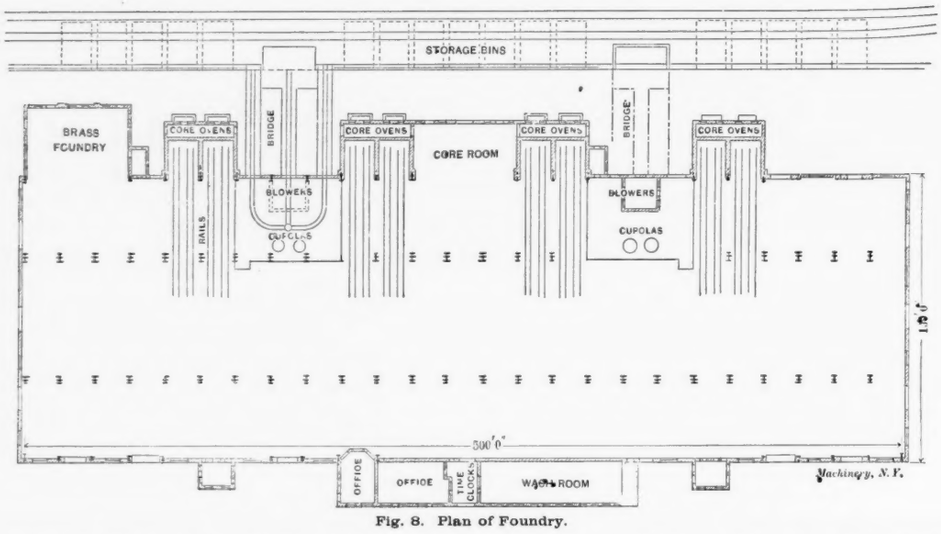


Fig. 8. Plan of Foundry.

All of the factory buildings are heated by the Evans system

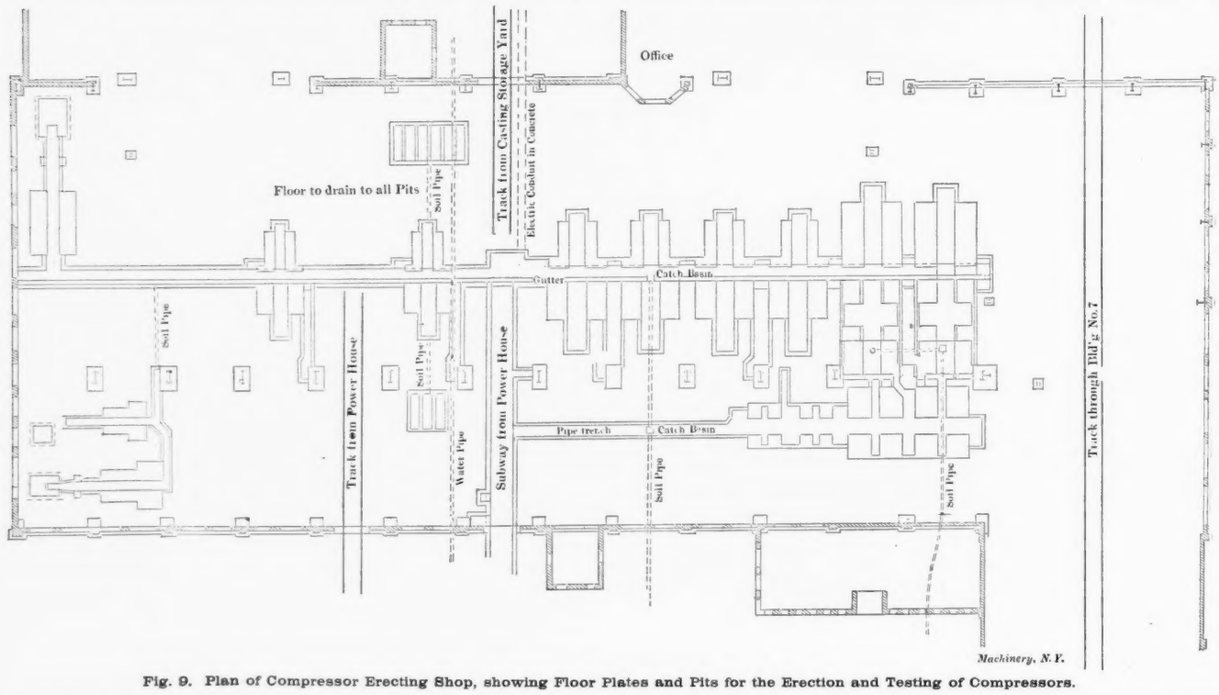
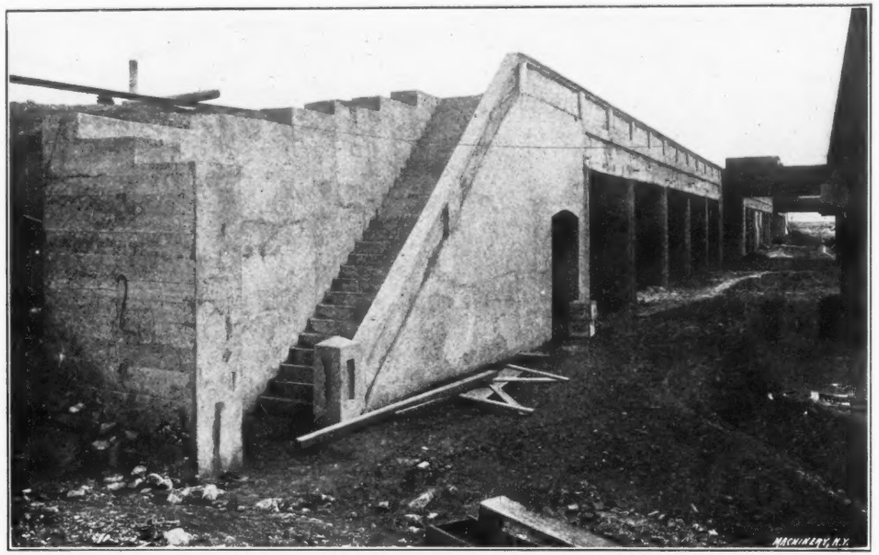
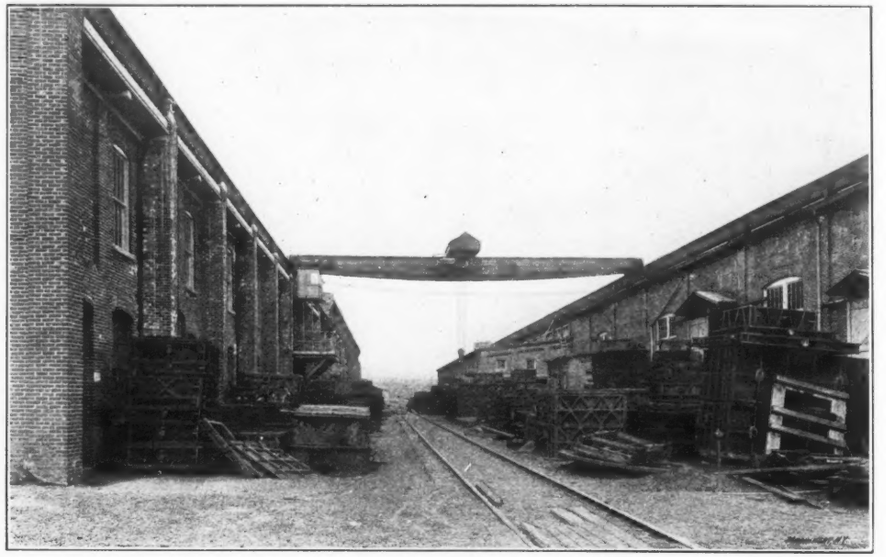


Fig. 9. Plan of Compressor Erecting Shop, showing Floor Plates and Pits for the Erection and Testing of Compressors.





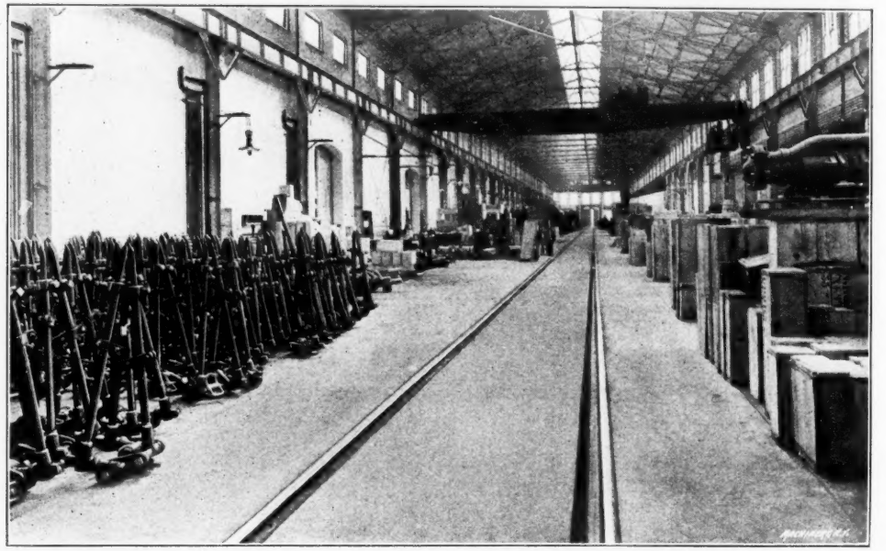


Fig. 10. Concrete Storage Bins. The top Bins are level with Foundry Charging Floors and connected with them by the two Bridges shown.

Fig. 11. Flask Yard between Foundry and Pattern Buildings. This yard is served by Traveling Crane and a Broad-gage Track.

Fig. 12. Interior of Compressor Erecting Shop, showing Testing Pits and Crane Tracks extending from the two Manufacturing Shops.

Fig. 13. Interior of Warehouse and Shipping Room connecting Compressor and Rock Drill Departments.

of hot water heating by forced circulation, installed by Evans, Almirall & Co., New York. The heating throughout is by means of direct radiation. The pipe coils are built up and attached to the walls, columns and overhead girders, and connected up either in multiple or parallel as circumstances

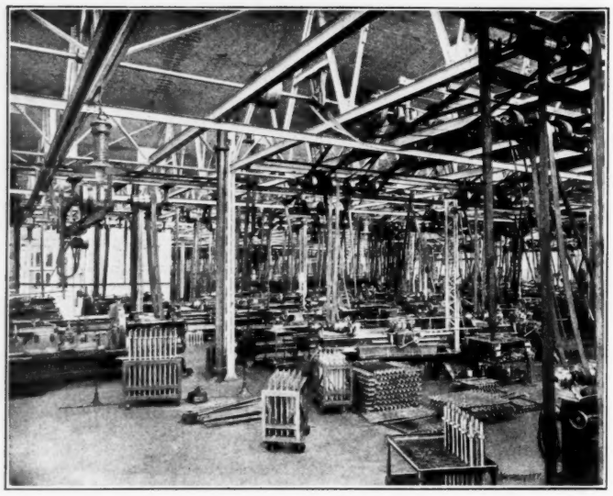


Fig. 14. Interior of Rock Drill Shop showing the Superior Lighting.

require. The most interesting thing about the installation of the heating system is the arrangement of the heaters and pumps in the power house and the method of using the exhaust steam from the engines when they are running either condensing or non-condensing. There are three tubular heaters similar in construction to that of an ordinary closed feed water heater. Two of these are arranged for use in connection with the exhaust steam from the engine and one of them is arranged for use in connection with live steam, the latter intended primarily for use on holidays and Sundays, when there is comparatively little exhaust steam available, or for nighttimes under the same conditions.

There are two main exhaust pipes, one of which is the free exhaust and leads directly to the atmosphere and the other is the exhaust to the condensers. On the individual exhaust connections from each engine, there is a Schutte free relief valve by means of which, in case the vacuum should break, any engine would automatically exhaust to the free air pipe, and thus prevent possibility of any accident thereto.

The condensing exhaust main is connected first to the two exhaust heaters referred to above, for the heating system and from thence to the condenser. The arrangement of the exhaust piping is such that the steam may be led either through these heaters or it may be by-passed around either or both, direct to the condenser. Under ordinary conditions the exhaust steam passes through the exhaust heaters first, and from thence, if any steam is left, to the condenser.

By this method, it is possible to vary the degree of the vacuum by running the condenser pump more rapidly or more slowly, and thus vary the temperature of the exhaust steam while still obtaining the economical effect of a condensing engine, due to the vacuum carried. The circulating water of the heating system is warmed accordingly, and can be carried at a temperature within 10 degrees of that of the steam. By this method the temperature of the water is varied to suit the outside temperature conditions. In extreme cold weather the engine units can be run non-condensing and the water heated to its maximum temperature of 200 degrees, but during the earlier winter months, and the early spring months, when some heat is carried a considerable vacuum can be maintained at the engine, and yet the heating accomplished at practically a nominal cost. The water is circulated throughout the mains and coils in the buildings by means of De Laval Steam Turbine units, which are provided in duplicate. No traps or other mechanical appliances whatsoever are required in any building outside of the power house.

The method of variable-speed operation for the machine tools of the plant is that of the four-wire system of the Crocker-Wheeler Co., which has already been fully described in these columns. In the compressor machine shops where the larger tools are located the individual drive is used almost

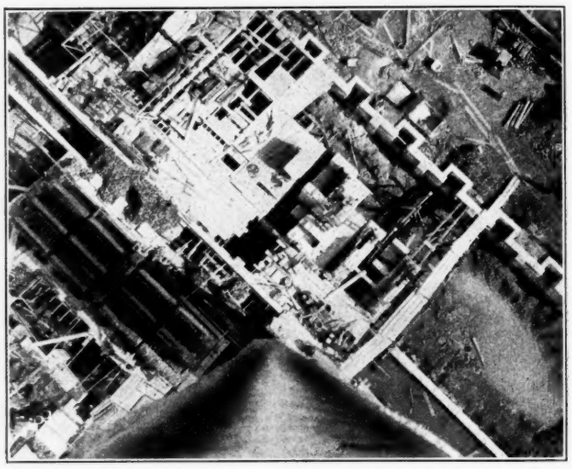


Fig. 15. It is all in the Point of View. Photograph from top of Chimney during Construction of the Plant.

to the exclusion of group driving. The current is distributed throughout these shops by running the wires in bituminized conduits laid in the cement floor a few inches below the sur-

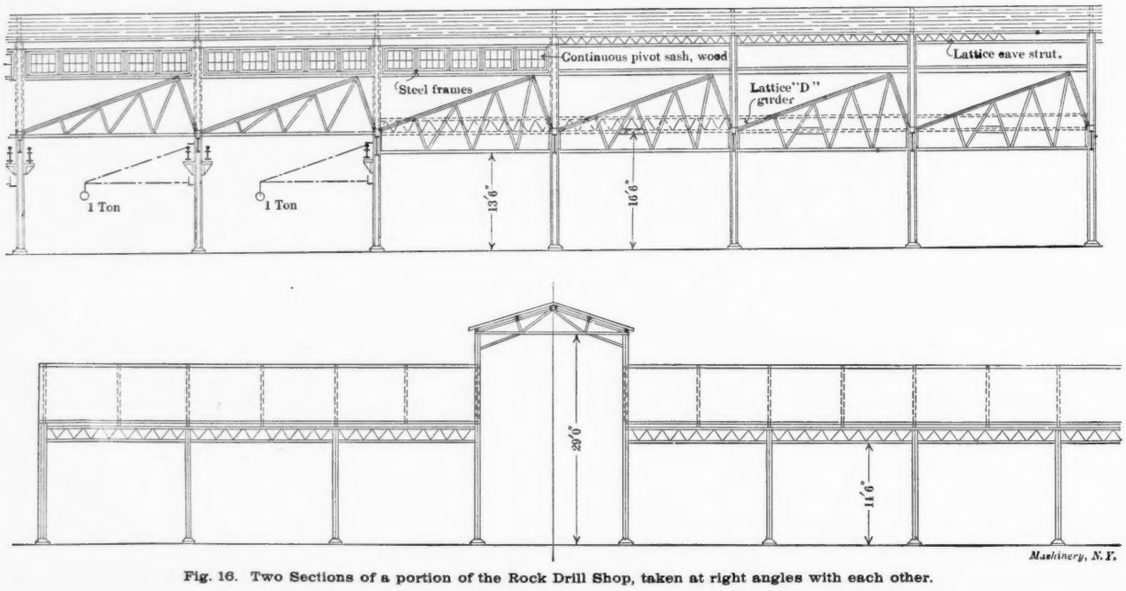


Fig. 16. Two Sections of a portion of the Rock Drill Shop, taken at right angles with each other.

face. Branch conduits run to a point near each column of the different buildings and terminate at floor openings, provided with cover plates, where leaders running to the tools in the immediate vicinity are easily connected.

In the rock drill shop group driving is employed almost to the exclusion of the individual drive. The motors are mounted under the roof and belted to the line shafting as shown in Fig. 17. The motors are supported on the lower members of the trusses and the line shafting is hung on short channels

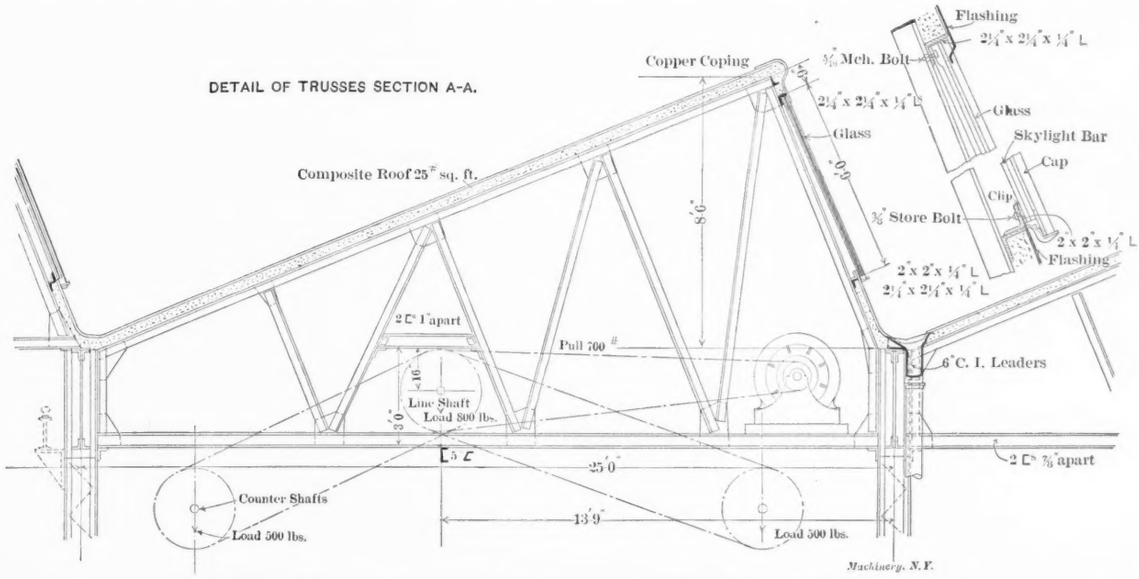


Fig. 17. Details of a Section of Saw-tooth Roof,, showing, also, the Arrangement of Motors and Shafting.

especially placed for this purpose. Countershafts hung from the lower members of the trusses are placed on each side of the line shaft, thus equalizing the belt pulls.

In Fig. 9 is a floor plan of the compressor erecting shop showing the elaborate foundations and pits that have been built in the floor, for the erection and testing of the air compressors. An interior view of the building appears in Fig. 10, and the piping will be noticed on the right. Near each pit are manifolds through which a compressor may be connected to either the high- or low-pressure air mains and thus compress air into the system instead of wasting it. There are also to be pipe connections leading to reservoirs outside the building in which air may be compressed to very high pressures, where a compressor is designed for special high-pressure duty and is to be tested at high pressure. The foundations of the testing department are laid in concrete.. Pits were dug at intervals and walled up, over which the compressors are to be erected, giving facility of access, opportunity for pipe connections, etc., and on each side of every pit are broad foundations on top of which are iron floor plates carefully leveled and grouted in.

The blacksmith shop has a complete equipment for producing forgings which are required in large numbers for the rock drill department, and there are also three hammers of about 2,500 pounds capacity for forging considerably heavier work. There are several drop presses with furnaces of the down-draft type.. A feature of the blacksmith shop is an auxiliary boiler receiving heat from the waste gases of the furnaces and generating steam for operating the hammers. The shop is served by a number of jib cranes and is well lighted and kept free from smoke by the exhaust system connecting with the furnaces.

The peculiarly severe duty required of rock drills makes it necessary to employ steel as free from internal strain as possible for all of the reciprocating parts. A rock drill is a portable machine made as light as is consistent with strength and durability which must be secured by employing materials of the very highest grade and treated by the most scientific processes. A large steel treating department has been equipped for this work containing annealing furnaces, gas hardening furnaces and oil tanks, etc., for annealing, tempering and hardening steel. The oil tempering process is extensively used, similar to the process employed by large steel works in treating high carbon steel used in gun construction; and, in fact, the same high grade material and advanced methods of tempering are required that are used in preparing the steel for the severe duty required in the cost defense and naval guns.

Building 15, adjoining the rock drill shop, is the testing-out plant for the drills; they are here set up and allowed to pound away on metal anvils and the separation of the department from the main structure relieves the employees of the latter from the annoyance of the jar due to the operation of the drills.

* * *

A paper read by S. F. Seager before the Michigan Engineering Society, January 11, 1905, on the Pintsch suction gas producer was designed to show the advantage of a suction gas producer over the older type of apparatus. Anthracite, coke or bituminous coal can be used as the fuel, the first named giving the cheapest production of gas. When the fire is first started a small blower, which is run by hand or foot power for units up to 150 horse power, is used. When the temperature has become high enough for proper gas generation, the gas is admitted to the engine and the suction stroke of the engine furnishes the draft through the fire. The heat of the CO gas is nearly all taken up in forming the steam which gives up its hydrogen to form the producer gas, and but little energy is lost in the scrubber which finishes the cooling process and extracts the dust particles. The gas next passes through the cleaner, which is filled with sawdust, when all the remaining impurities are extracted, the claim being made that where anthracite is used in the generator, an engine can be run six months without needing cleaning. In connection with the apparatus the engine is equipped with governor control on the admission of both air and gas. The claimed advantages of the suction gas producer over the pressure producer are: that owing to the partial vacuum which exists in every part of the apparatus there is no leakage of gas, clinkers and ashes can be removed at any time during the working, and only the actual amount of gas used by the engine is generated. Only a few of these plants have so far been installed in this country, but they are coming into common use in Belgium and Germany, where the system originated. Tests have shown that for units of 50 horse power, 1 pound of anthracite will produce one horse-power hour, and with larger units this can be cut down to 0.75 or 0.80 pound.

* * *

Statistics received by the Department of Commerce and Labor, through its Bureau of Statistics, indicate that the world's output of coal in 1903 was 864,000,000 long tons, of which the United States produced 319,000,000 tons.

NOVEL MAGNETIC CLUTCHING AND SPEED ACCELERATING DEVICES OF THE CUTLER-HAMMER MFG. CO.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., has been carrying on experiments for several years in the development of magnetic couplings and accelerators. These efforts have been successful, and the Cutler-Hammer Clutch Co. has now been organized for the manufacture and sale of the apparatus designed along these lines.

The Cutler-Hammer magnetic clutch is a device applicable wherever the shafts to be coupled are at rest or both are running at the same speed when the coupling takes place. They can also be used to cut out a machine or section of shaft when in rotation. The magnetic speed accelerators fulfill the functions of the ordinary friction clutch, and in addition have a much wider application. They are used, generally speaking, for connecting a shaft to be driven to a driving shaft when the driven shaft is at rest or is rotating at a speed different

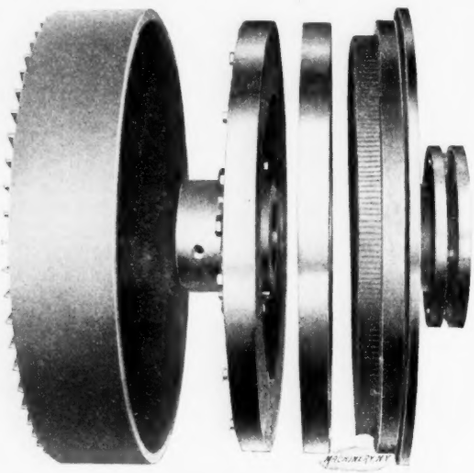


Fig. 1. Parts of Magnetic Accelerator in their Proper Relation.

from that of the driving shaft. This coupling is followed by a smooth acceleration of the speed of the driven shaft, up to synchronism with the driving shaft, or, if desired, to some predetermined speed less than that of the driving shaft. This result is attained by the production of a torque having two components, one due to friction and one due to eddy currents induced in the armature plates by the magnetism of the field, which is especially constructed to secure this result. The induction component of the torque is a maximum at the moment of starting, dropping off as the driven member attains speed. At the same time the torque due to friction, which remains sensibly constant during the acceleration, increases suddenly as the driven shaft approaches full speed, on account of the change from the "friction of motion" to the "friction of rest." Thus an increased torque is produced at the two points where it is most needed in practice, at the time of starting the driven member from rest, and at the time of bringing the driven part to full speed. When the accelerator is used as a speed changing device the torque due to friction is largely eliminated by mechanical or electromagnetic means.

The parts of the magnetic clutch, first mentioned, are shown in Fig. 2. They consist of two cast steel rings, carried on steel plate webs which are bolted to the shafts to be coupled. One of these rings, called the field ring, has an annular slot in which the magnetizing coil is secured; the other, which acts as the armature or keeper, is so mounted as to be separated from the field member, when the coupling is not energized, by an air gap of from 1-16 to 3-16 of an inch. The spring of the steel plate webs carrying the field and armature allow these members to spring together when the coil circuit is closed, the magnetism induced holding them by a strong pressure. When the circuit is interrupted the spring of the plates separates the surfaces. This clutch is shown in section, mounted on the two shafts, in Fig. 4.

A sectional view of the magnetic accelerator, mounted in position, is shown in Fig. 3. The parts of the accelerator, placed in proper relation ready to be assembled, are shown in Fig. 1. These are, from left to right, the oil casing, field, magnetizing coil, and the back plate with flange to which the oil casing is attached. It is seen that this arrangement is opposite from that of Fig. 3.

The field is made up of the back plate, outer and inner field-rings, magnetizing coil and contact rings. The back plate, shown to the left of Fig. 3, is a cast steel plate, with a hub

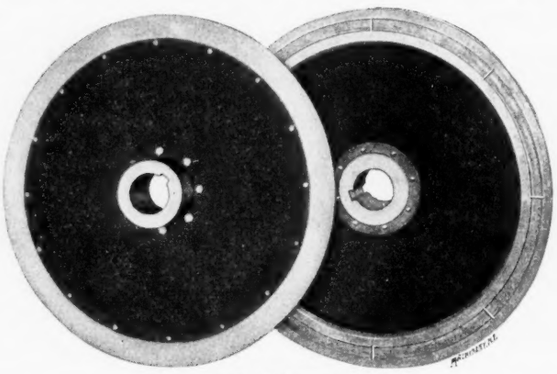
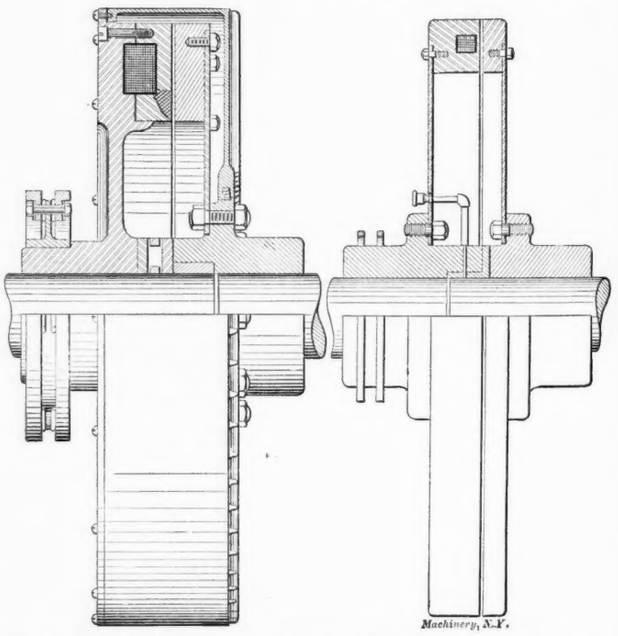


Fig. 2 Parts of Magnetic Clutch.

which is bored and key-seated to receive the shaft or sleeve on which the device is to be mounted. The plate has an annular groove which carries the magnetizing coil; the contact rings, to which the coil terminals are attached, being mounted on the hub. The back plate is faced off to receive the field rings. The latter are cast steel rings having radially projecting poles. When assembled, the polar projections of the outer and inner rings intermesh, the inter-polar spaces being filled with some non-magnetic metal, such as babbitt metal. When thus assembled and finished the inner and outer field rings with polar projections separated by babbitt form a continuous surface for the bearing face. When mounted on the back plate they serve to protect the magnetizing coil, which is completely enclosed, though not surrounded by a complete magnetic cir-



Figs. 3 and 4. Half-sectional Views of Magnetic Accelerator and Clutch.

cuit. The appearance of the field castings, in the rough and after being babbitted, is shown by the middle and right hand figures in Fig. 5, while the back plate with the magnetizing coil is shown in the left hand figure.

The effect of this construction is, the coil being entirely surrounded by iron, that the current through the winding and consequently the strength of the magnetic field in the inducing or field member, is retarded, when the circuit through the coil is completed, on account of the large amount of induction. This prevents the sudden acceleration of the driven member.

By the radial overlapping of the magnet winding by the polar faces, the entire surface of the clutch is utilized as a friction surface. The magnetic effect of the disposition of the polar surfaces shown is to cause the lines of force passing from the polar surfaces to the armature to move in substantially tangential directions, the eddy currents induced in the armature being thus so disposed that the reacting lines of force produced thereby are tangential. Thus the maximum turning effort is secured, the tangential components of the lines of force being those which tend to produce rotation. Furthermore, this disposition of the polar surfaces aids in causing the members to quickly separate when the coil windings are deprived of current, as by the arrangement of the polar surfaces, the magnetic field is divided into a large number of individual magnetic circuits, which aid in causing the rapid disappearance of the residual magnetism in the armature.

Fig. 5. From Left to Right Back Plate of Magnetic Accelerator with Magnetizing Coil, Field Castings in the Rough, and Field Castings after being Babbitted.

The armature is a cast-iron plate, adapted to be drawn into engagement with the field when the latter is energized. The mounting of the armature, as shown in Fig. 3, is a novel feature of the accelerator. The armature is bolted on the outer circumference of a disk of steel plate, which in turn is bolted to a flange on the hub. The hub may be keyed or loose, but has practically no end play in either case. When the accelerator is energized, the spring of the steel plate allows the armature to move laterally across the slight intervening space, and engage the field. When the circuit is opened the spring of the plate acts to release the clutch. A roller or thrust bearing is provided to maintain the spacing between the faces of accelerators intended for heavy service.

The oil casing is a cast iron shell, bolted to the back plate and enclosing the armature. It is provided with tapped holes for filling and draining, and carries oil for lubricating the faces. The oil also serves the purpose of a cooling medium, absorbing heat and giving it out through the walls of the casing, which is provided with a large number of ribs. These serve the double purpose of increasing the radiating surface and acting as fan blades to increase the circulation of air. The employment of the oil between the armature and magnet member lessens the danger of cutting. It has been found that this use reduces the torque but slightly.

The magnetizing coil is wound of double cotton covered wire, is well insulated, and is securely anchored to prevent shifting. The leads are brought out through insulating bushings, and are of lead encased wire.

In practice these accelerators find their readiest application to that class of service where it is desired to control moderate or large sized units by some form of automatic device, such as a float switch, relay or electrical contact of any kind. For most work they can be thrown directly across the line without danger from shock or jar, as it is practically impossible to produce a sudden jerk with them. In connection with gear trains this device is also used to operate a machine at different speeds, and this arrangement has proven very satisfactory in practice.

The accelerators are easily balanced for much higher speeds than that for which the ordinary clutch is available. A small current suffices to energize the magnetizing coil, two amperes being sufficient to control a 100 H. P. unit at ordinary speed. Adjustment for wear is unnecessary on account of the large wearing surfaces. One of these clutches has been in successful operation in the steel plate mill of the Riter-Conley Co., Leetsdale, Pa., for three months, starting a 100 H. P. load over 200 times a day, without need of adjustment.

The design, construction and many applications of these accelerators are protected by patents lately issued to the Cutler-Hammer Mfg. Co., covering inventions of Mr. H. H. Cutler, chief engineer of the company. Among the applications patented are a method of power transmission, using a magnetic speed accelerator which possesses the inherent property of gradual acceleration; means for starting synchronous motors under load, and for starting single or polyphase motors under load without disturbing the power factor on the lines. Other patents cover methods of operating trains of cars arranged on the multiple unit plan, so that all the motors may be started, stopped and reversed from any car on the train, and a method of improving the power factor on a line in starting alternating current motors under load, utilizing the controllable inductive and frictional slip of a magnetic accelerator mounted between the motor and its load.

* * *

GOLD FROM SEA WATER.

The fact that streams and rivers are continually washing away the earth's surface, and carrying its constituent elements to the oceans, make them great repositories of all the minerals and metals known. Just as surely as the alluvial deposits on certain rivers are gold-bearing, just so sure is it that these rivers have carried into the sea many times the amount of gold found along their beds. Chemical analyses have confirmed this deduction, inasmuch as the average amount of gold found in a ton of sea water is something like 1 grain, worth about 4 cents. This is a small sum but multiplied by the tons of water estimated to be contained in the ocean—60,000,000,000,000—it makes an amount well calculated to stagger the imagination. Many wild and chimerical schemes have been evolved for recovering gold from sea water, most of which were far more successful for drawing gold from the pockets of the investors than from the water. An announcement made in the daily papers of a new process developed abroad, which has the alleged sanction of Sir William Ramsay, has attracted world-wide attention, nevertheless, for it is pretty generally believed that it *is* a possibility to secure some measure of the great amount of gold in sea water. A recent English consular letter refers to a report that a syndicate has acquired favorable sites on the English and Irish coasts for over fifty miles of foreshore. It is explained that it is necessary to acquire foreshore rights in order that the water secured for the new gold separation process shall be as free as possible from river factory contamination.

* * *

The Halifax Dock Yard in Nova Scotia, which was started in 1758 and completed in 1770, has recently been closed and 300 employees dismissed. It will no longer be used as headquarters for the British navy, hence has no further usefulness as a naval repair station.

A PUNCH FOR THE MANUFACTURE OF WASHERS AND SPECIALTIES.

The Krips-Mason Machine Co., Philadelphia, Pa., have placed a machine on the market for the manufacture of washers, armature disks and electric and hardware specialties. The general lines of the machine are those of a punch of substantial

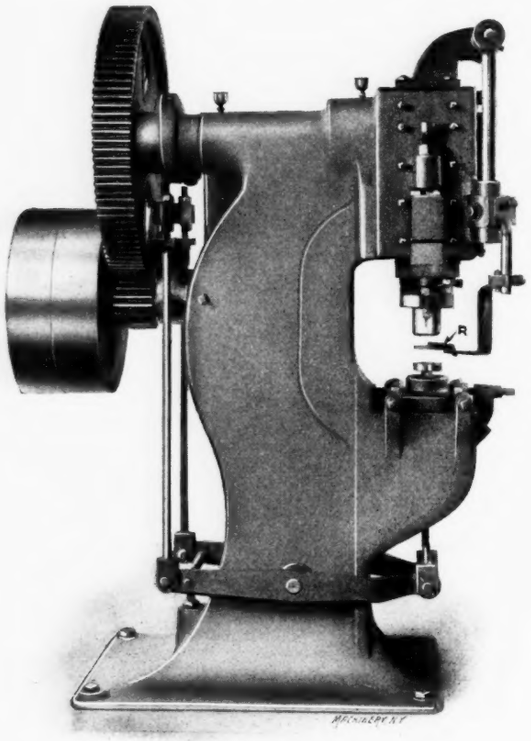


Fig. 1.

construction, and it is intended to be fitted with punches and dies of special design made under the patents of Mr. Joseph M. Mason; but these are easily removed and other punches and dies may be substituted if desired, or the machine may be fitted for shearing. It is thus adapted to a wide range of work and can be made a tool of general utility, so that it can be kept busy in almost any machine shop upon one kind of work or another.

The machine was at first intended solely for the manufacture of washers from various materials, but punches and dies, upon the principle of those designed by Mr. Joseph M. Mason for producing washers, have been made for more complicated pieces and operate very successfully and rapidly. The machine cuts and punches at one stroke and may be fitted either with single or multiple dies as desired. In working up scrap metal into washers, however, it is more economical to punch a single washer at a stroke, and any concern using metal plate or sheet metal can work up the scrap in this way and thereby affect a saving. In fact, an important adjunct of the business of the Krips-Mason Co. is the production of washers from scrap metal with their own machines, which they operate both at their own plant and at the plants where the scrap metal is produced. They have recently taken contracts for working up several hundred tons of metal in this way, although their business is primarily that of manufacturing the machine itself.

In Fig. 3 is a sectional view of a multiple die used in punching washers; the head *A* is given a vertical reciprocating motion by the eccentric *B* in the usual manner, and the upper die *C* is bolted to the lower end of the head. A bolster *D* bolted to the frame of the machine carries a series of lower dies *E*, which, in conjunction with the upper die *C*, cuts out the washers. Centrally arranged in each of the openings *F* of the upper die is a punch *G*, which in conjunction with the central opening in the lower die, forms the holes of the washers. The sleeves *H* in the upper die for ejecting the washers from the upper die are fitted with the usual pins to prevent the washers from adhering to them.

The head of the machine is slotted for the bar *K* which rests upon the two vertical pins supported by the flat plate *L* which bears upon the tops of the several sleeves. The punches and dies come together simultaneously and cut the washers at one stroke and upon the return of the die head the bar *K* strikes the two adjustable screws *M* attached to the frame,

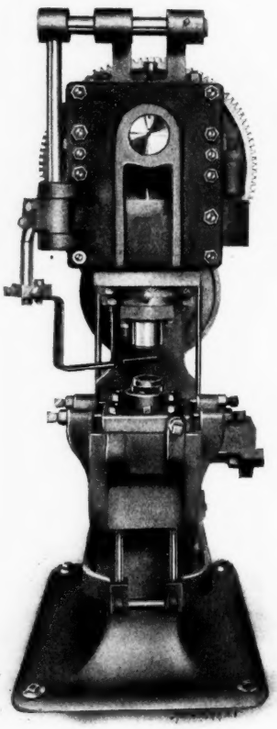


Fig. 2.

and forces out the washers. The stripper plate *N* frees the stock from the lower dies enabling it to be fed along for the next stroke.

In Figs. 1 and 2 will be noted the method of bolting the

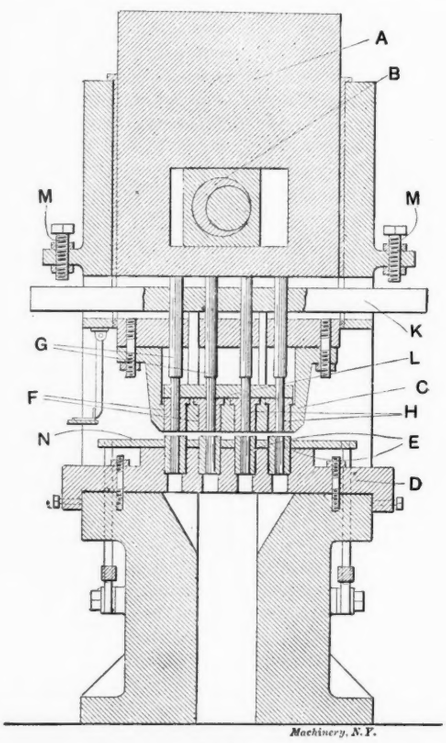


Fig. 3.

upper and lower dies to the machine. The stripper plate for the lower die is operated by the levers at the bottom of the machine which receive their motion from a cam on the shaft with the large gear. A carrier *R*, Fig. 2, swings back and forth in a horizontal plane and carries the washer, when it is forced out of the upper die to a receptacle placed at the side of the machine, where the finished product accumulates.

It is possible for a person to operate the punch without in any way endangering himself, since there is no reason for touching the stock or the finished product at a point anywhere near the dies. The machine is so far automatic that it can be operated by a boy and the several adjustments are easily made. Washers or other metal pieces produced have no burr on their lower edges and are flat and need no rolling after they come from the machine. Owing to the firm manner in which the stock and punches are supported, the machine will produce washers or other pieces from soft material like brass, fibre, leather or paper, as well as from steel or iron plate.. It will also punch cold nuts as well as thinner material. Armature disks up to 6 inches in diameter have been successfully produced at one stroke, and much larger sizes are contemplated. At present the machine is regularly built in four sizes, taking work up to 6 inches outside diameter.

* * *

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION.

The semi-annual convention of the National Machine Tool Builders' Association was held at Washington, D. C., on April 11th and 12th. There was a good representation of firms and the Bullard Machine Tool Company joined at this session. At the first session the routine business was transacted, reports of committees were read and a paper was presented by W. P. Davis, upon conditions of trade, in which he stated that the foreign demand for large tools is comparatively light, but that orders for small tools are fairly satisfactory. He stated that dealers claim to have had the same amount of business in 1904 as in the previous year, but that sales were made upon a basis of smaller profits. The belief was expressed that after the cessation of hostilities in Manchuria there would be an increased demand in Russia and Japan for machine tools which we should be prepared to take advantage of.

At the succeeding sessions the leading subjects discussed were the conditions of an up-to-date foundry for machine tool manufacture; the acquisition of the world's markets; the question of tariffs and the discrimination against the American manufacturer of machinery; the apprenticeship question; the revision of prices; the motor drive and belt drive for machine tools.

There are few machine tool manufacturers in the country having their own foundry and the question as to whether it is advantageous to the manufacturer to have his own foundry was discussed at some length. The question of the world's markets led to a suggestion that it would be advantageous to train young men especially for traveling abroad to introduce machinery; and that they should learn foreign languages and become familiar with methods of buying and selling in different countries so that they could not only act as salesmen but assist in the preparation of literature to be distributed abroad.

Mr. G. Herbert Condict of the Electro-Dynamic Co., Bayonne, N. J., presented some interesting data upon machine tool driving. In pointing out the advantages of the motor-driven tool, he stated that with the belt drive it had been practically demonstrated that the average loss in the belting and the shafting amounted to at least 50 per cent. of the total power. To substantiate this he cited a number of instances from actual practice, where power determinations of installations had been made. One of these was a plant entirely equipped with individual motor drives in which only ½ the power was required that had been calculated to be necessary in case the shop were to be equipped with the belt drive. Another instance was that of a shop where it was desired to operate only a few tools upon occasion, for which about 25 horse power would be required. An auxiliary engine of 35 horse power was connected up for the work and it was found that the engine would not turn over the shafting, and upon a careful investigation, the transmission machinery was found to absorb 50 per cent. of the power of the main engine. Another case, an extreme one, was where as much as 83 per cent. had been absorbed by the transmission machinery. In electrical transmission, assuming the shop to be operated at say, 75 per cent. of the generator capacity, so that a good efficiency can be obtained from the generator itself, the loss between the engine shaft and the line will be about 6 per cent.,the line loss 2 per cent. and the average loss in the motor itself of 17 per cent., assuming it to be an efficient motor. The loss between the motor shaft and the shaft of the tool itself, where a single power of gear or a general drive is used amounts to 5 per cent., so that the total loss between the engine shaft and the tool shaft would be about 28 per cent. Mr. Condict dwelt upon a number of other points and referred briefly to the operation of the interpole motor made by his company.

The subject of the tariff was taken by Mr. Fred A. Geier, who outlined in detail the tariff rates of different countries upon machine tools, and told where and to what extent it might be expected that the rates would increase. At the present time the United States has the advantage of the "most favored nation" clause incorporated in the treaties which we have, at some time or other, concluded with the leading countries. By this clause, if two nations agree upon mutual concessions through the negotiation of a commercial treaty, other countries having treaties may participate in the concessions granted by the two nations in question. This has secured us favorable rates in certain countries, including Russia. In 1901, however, an extra import duty was levied upon Russian sugar to offset a Russian bounty upon exports of sugar, but, in return, Russia has increased the duty on certain products, among them iron, steel, etc. In France two schedules are in effect, a higher and a lower one, and a reciprocity treaty to secure the lower rate on certain American products, among them machine tools, has failed because of the objection by certain manufacturers in this country to the importation of hosiery and jewelry from France as called for by the treaty. Germany, having taken a forward step in manufacturing, is now in a better position than heretofore to supply her own markets, and the tariff is to go into effect in 1906 with heavy duties on foreign products. Also in Austria-Hungary, there is to be a higher rate. Mr. Geier pointed out that the various tariffs are so arranged that concessions can be made to nations desiring to enter into the reciprocity treaty, and that our salvation lay along the lines of an amicable adjustment of treaties, both here and abroad, through reciprocity treaties rather than by attempting to wage warfare against foreign manufacturers.

* * *

INTERESTING PHOTOGRAPHS OF STEAM TURBINE BLADES.

The Westinghouse Machine Co., East Pittsburg, Pa., have recently taken photographs of the interior of the first steam turbine put into practical use in America, this being the first turbine built by them for practical service. The machine was installed in 1899, and has been in continual service for 24 hours a day for a period of over 5 years. The steam supply for this turbine has not been favorable to longevity of service, since the steam has always been excessively wet, owing probably to a long run of steam piping, and it has frequently occurred that creek water had to be put into the boilers, owing to the failure of a steady supply. This water is extremely acid and has so bad an effect upon the turbine that the outer surface of the balancing pistons of the turbine had to be coated with white lead to prevent their corrosion from this cause. Furthermore, owing to the accumulation of sediment carried over when this water was used, the turbine has had to be frequently cleaned by air blasts. In view of these facts it would seem that this turbine was subjected to about as severe a test as a machine could well be put to in practice, and the photographs showing the conditions of the blades are, therefore, of unusual interest as indicating what may be expected in the way of durability with turbines of this type.

In Fig. 1 is a view of a portion of the rotor taken at the low-pressure end where the steam is the most moist and cutting action would be expected if anywhere. In Fig. 2 is a view of a portion of several rows of blades belonging to the

upper half of the stator—that is, blades in the cover of the turbine. It is evident from the appearance of the blades in the photographs, that erosion of the blades, if such exists, is not sufficient to be apparent from these views. In order to illustrate this more fully, however, two vanes were deliberately broken out of the 8th and 12th rows, respectively, of the low pressure barrel for examination, and it was found that their

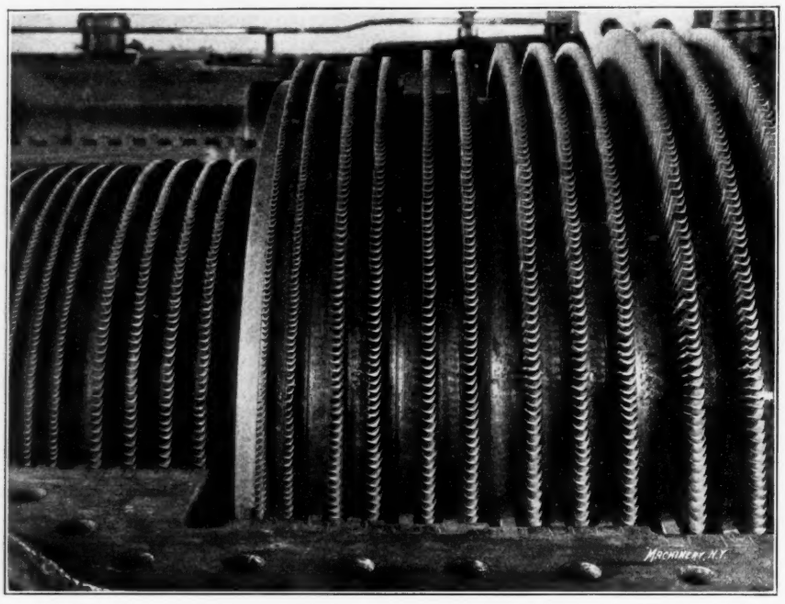


Fig. 1. Rotating Blades.

Fig. 2. Fixed Blades.

Photographs of the Blades of a Turbine after five years' Service.

metallic surfaces had retained their original polish and there was no trace of wear and no reduction in the cross section of the vane.

The company informs us that the only effect traceable to steam wear on the vanes is to be found in the case of those which have been set slightly out of line with the remaining ones of their particular ring. In such cases the area projecting into the steam case becomes slightly scored upon the advance side. The effect has been the sharpening of the edges to such fineness, that a piece of heavy cord can be severed by them. In no case has the surface of the metal been worn away to an appreciable extent. One of the vanes broken out is shown in Fig. 3, where it is photographed so that it may be

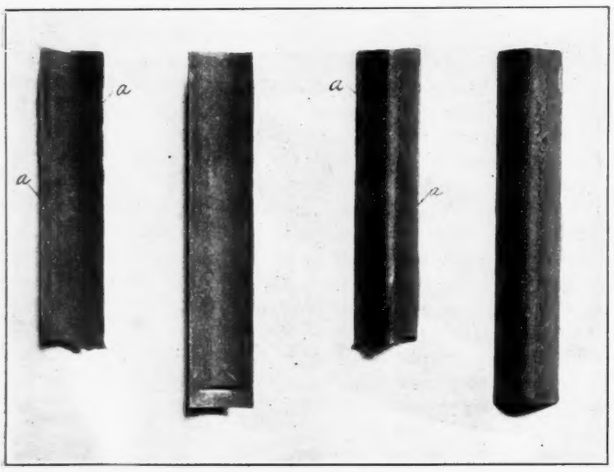


Fig. 3. Blades Broken from Low-pressure end of Turbine, compared with new Blades. These showed the most Wear of any Blades in the Turbine. Most of the Blades showed no Wear.

compared with a new vane and was selected because it showed the effect of wear as much as any vane that can be found in the turbine. The wear is scarcely perceptible in the illustration, but it occurs chiefly at the points marked *aa*.

The foregoing facts are taken from an open letter issued by the Westinghouse Machine Co., sent to the press and called out in part by the publication of illustrations of vanes from Parsons turbines, both as made by their company and by firms abroad, in which apparently the blades are badly eroded, the inference being that the cutting was due to the action of steam. It is contended in this letter that where a badly worn vane is found, it must be due to something besides the action of the steam, since the velocity of steam in this turbine is so low as to produce no bad effect. In support of this claim illustrations in Fig. 4 are shown of a badly cut blade which is compared with a similar new blade. The damaged blade was taken from an experimental turbine in which several rows of blades were damaged by the accidental distortion of casing.

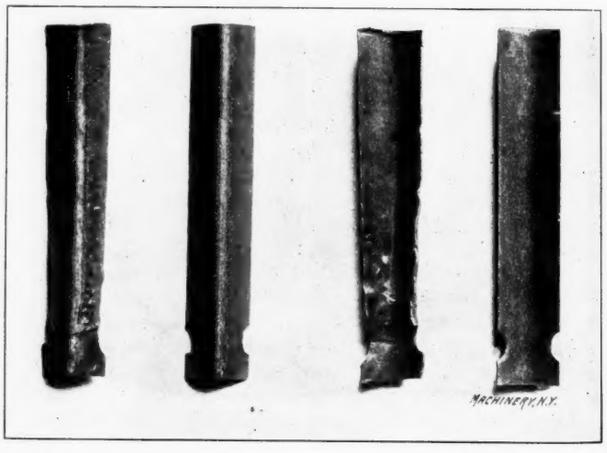


Fig. 4. New and Damaged Blades from an Experimental Turbine—Damage was not caused by Erosion, but by an accident to the Turbine.

The blade shown is not one of those damaged from this cause but its surface was worn away by flying particles of the damaged vanes in passing through the turbine. If unaccompanied by an explanation of the cause of this action, the illustration would lead to an erroneous impression.

* * *

The report of Chief Mason, of the Bureau of Ordnance states that black powder is now only used in the Navy for ignition, saluting purposes and for filling shells, its manufacture for other purposes having been entirely discontinued. Brown powder is no longer used, being replaced with a smokeless powder. Cordite, which was first used during the Spanish war, has proved unsatisfactory. It is uncertain in its action, and has great erosive effect on the bores of guns.

THE STEEL-HARDENING METALS.*

JOSEPH HYDE PRATT.

There are included under the head of steel-hardening metals, nickel and cobalt, chromium, tungsten, molybdenum, vanadium, titanium, and uranium, which are named in the order of the importance of their production and use for steel-hardening purposes.

The special steels resulting from these additions vary among themselves, having individual properties of tensile strength and elastic limit, of conductivity, heat and electricity, of magnetic capacity and of resistance to impact, whether as shell or as armor plate. It was only about twenty years ago that the first of these metals, nickel, began to be used to any extent for the purpose of hardening steel, but since their introduction their use for this purpose has continued to increase steadily. Experiments are still being carried on with some of these metals in order to determine their actual commercial value with regard to the qualities that they impart to steel. In the arts it is the ferro-alloy of these various metals that is first prepared and is then introduced in the required quantity into the manufactured steel, but this ferro-alloy is never added to the molten mass during the manufacture of the steel. All these metals give characteristic and distinct properties to steel, but in all cases the principal quality is the increase in the hardness and the toughness of the resulting steel. Some of the metals—as nickel, chromium and tungsten—are now entirely beyond the experimental stage and are well established in the commercial world as definite steel-hardening metals, and new uses are being constantly devised for the different steels, which are causing a constant increase in their production. Others, as molybdenum and vanadium, though they have been proved to give certain positive values to steel, have not been utilized to any large extent as yet in the manufacture of molybdenum or vanadium steel, partly on account of the high cost of the ores containing these metals. Titanium and uranium are still in the experimental stage; and, although a good deal has been written as to the value of titanium as an alloy with steel, there is at the present time very little if any of it used in the manufacture of a commercial steel.

Since the introduction of the electric furnace and the consequent methods that have been devised for reducing ores, it has become possible to obtain these ferro-alloys directly from the ores by reducing them in the electric furnace, and hence experiments have been conducted on a much larger scale than formerly.

Manganese Steel.

Besides the use of ferromanganese for the chemical effect which it produces in the manufacture of steel in eliminating injurious substances, it is also used in the production of a special steel which possesses to a considerable degree combined hardness and toughness. Such steel contains from 0.8 to 1¼ per cent of carbon and about 12 per cent of manganese and is known as "Hadfield manganese steel." If only 1.5 per cent of manganese is added, the steel is very brittle, and the further addition increases this brittleness until the quantity of manganese has reached 4 to 5.5 per cent, when the steel can be pulverized under the hammer. With a further increase, however, of the quantity of manganese, the steel becomes ductile and very hard, reaching its maximum degree of these qualities with 12 per cent of manganese. The ductility of the steel is brought out by sudden cooling, a process the opposite of that used for carbon steel. These properties of manganese steel make it especially adapted for use in the manufacture of rock-crushing machinery, safes, and mine car wheels.

Nickel Steel.

Nickel finds its largest use in the manufacture of special nickel and nickel-chromium steels, and the use of these steels for various purposes in the arts is constantly increasing. The greatest quantity of nickel steel is used in the manufacture of armor plate, either with or without the addition of chromium. There is probably no armor or protective deck-plate made which does not contain from 3 up to 5 per cent of nickel. Nickel steel is also used for the manufacture of ammunition hoists, communication tubes, aud turrets on battleships, and for gun shields and armor.

The properties of nickel steel or nickel-chromium steel that make it especially adapted for these purposes are its hardness and great tensile strength, combined with great ductility and a very high limit of elasticity. One of the strongest points in favor of a nickel steel armor plate is that when it is perforated by a projectile it does not crack. The Krupp steel, which represents in composition about the universal armor-plate steel, contains, approximately, 3.5 per cent of nickel, 1.5 per cent of chromium, and 0.25 per cent of carbon.

Another use for nickel steel that is gradually increasing is the manufacture of nickel steel rails. During 1903 there were over 11,000 tons of these rails manufactured, which were used by the Pennsylvania, the Baltimore & Ohio, the New York Central, the Bessemer & Lake Erie, the Erie, and the Chesapeake & Ohio railroads. These orders for nickel steel rails resulted from the comparison of nickel steel and carbon-steel rails in their resistance to wear during the five months trial of the nickel steel rails that were used on the Horseshoe Curve of the Pennsylvania Railroad. The advantages that are claimed for the nickel steel rail are its increased resistance to abrasion and its higher elastic limit, which increases the value of the rail as a girder. On sharp curves it has been estimated that a nickel steel rail will outlast four ordinary rails.

Nickel steel has also been largely adopted for forgings in large engines, particularly marine engines, and it is understood that this is now the standard material for this purpose in the United States navy. There is a very great variety of these forgings and drop forgings, which include the axles and certain other parts of automobiles, shafting and crankshafts for government and merchant-marine engines and stationary engines, for locomotive forgings, the last including axles, connecting-rods, piston-rods, crank-pins, link-pins, and pedestal cap bolts, and for sea-water pumps.

Another important application that is being tried with nickel steel is in the manufacture of wire cables, and during the last year such cables have been made by the American Steel and Wire Co., but no comparison can as yet be made between them and the ordinary carbon-steel cables with respect to their wearing qualities.

In the manufacture of electrical apparatus nickel-steel is beginning to be used in considerable quantity. The properties of this steel which make it especially valuable for such uses are, first, its high tensile strength and elastic limit, and, second, its high permeability at high inductions. Thus steel containing from 3 to 4 per cent of nickel has a lower permeability at low inductions than a steel without the nickel, but at the higher inductions the permeability is higher. A notable instance of the use of this material is in the field rings of the 5,000 H. P. generators built by the Westinghouse Electric and Manufacturing Co. for the Niagara Falls Power Co. These field rings require very high tensile strength and elastic limit, and in order to reduce the quantity it is desirable that they have high permeability at high inductions. This result was secured by using a nickel steel containing approximately 3.75 per cent of nickel. Steel containing approximately 25 per cent of nickel is nonmagnetic and has a very low resistance temperature coefficient. This property is occasionally of value where a nonmagnetic material of very high tensile strength is required. The high electrical resistance of nickel steel of this quality, together with its low-temperature coefficient, makes it valuable for electrical resistance work where a small change in the resistance due to change in temperature is desirable. The main objection to using nickel steel for this purpose is the mechanical defects that are often found in wire that is drawn for this quality of nickel steel.

For rock drills and other rock-working machinery nickel steel is used in the manufacture of the forgings which are subjected to repeated and violent shocks. The nickel content of the steel used in these forgings is approximately 3 per cent, with about 0.40 per cent of carbon. The rock drills or bits are made for the most part of ordinary crucible cast steel which has been hardened and tempered. There is a field for investigation here in respect to the value of some of the special

* From paper in "Mineral Resources of the United States," issued by the U. S. Geological Survey, 1904.

drills in the manufacture of rock-drill steels or bits. A nickel-chrome steel is now being made which is used to some extent in the manufacture of tools.

Nickel steel in the form of wire has been used quite extensively and for many purposes—for wet mines, torpedo defense netting, electric lamp wire, umbrella wire, corset wire, etc.—where a non-corrosive wire is especially desired. When a low coefficient of expansion is desired—as in the manufacture of armored glass, in the mounting of lenses, mirrors, lever tubes, balances for clocks, weighing machines, etc.—nickel steel gives good satisfaction. For special springs, both in the form of wire and flats, a high carbon nickel steel has been introduced to a considerable extent. Nickel steel is also being used in the manufacture of dies and shoes for stamp mills, for cutlery, table ware, harness mountings, etc.

Nickel steels containing from 25 to 30 per cent nickel are used abroad to some considerable extent for boiler and condenser tubes and are now being introduced into this country. The striking characteristic of these steels is their resistance to corrosion either by fresh, salt, or acid waters, by heat, and by superheated steam. The first commercial manufacture of high nickel steel tubes began in France in 1898, and was followed in Germany in 1899; but it was not until February, 1903, that these tubes were made in the United States. Since then, however, Mr. Albert Ladd Colby states:

"The difficulties of their manufacture have been so thoroughly overcome that the 30 per cent nickel steel, seamless, cold-drawn marine boiler tubes, now a commercial proposition, are made in practically the same number of operations, and with but a slightly greater percentage of discard than customary in the manufacture of ordinary seamless tubes, and, furthermore, the finished 30 per cent nickel steel tube will stand all the manipulating tests contained in the specifications of the Bureau of Steam Engineering, United States Navy Department, for the acceptance of the carbon-steel seamless cold-drawn marine boiler tubes now in use. In addition, the nickel-steel tubes have a much greater tensile strength."

Although the first cost of the nickel steel tubes for marine boilers is considerably in excess of the carbon-steel tubes, yet, on account of the longer life of the nickel-steel tubes, they are in the end cheaper than the others. At the present time 30 per cent nickel-steel tubes cost from 35 cents to 40 cents per pound, as compared with 12 cents to 15 cents per pound for the corresponding mild carbon-steel tubes. Thus their initial cost, when used in the boilers of torpedo-boat destroyers, is 2.13 times as great as the other kind and 2.43 times as great when used in the boilers of battleships, but the nickel steel tubes will last two-and-one-third times longer than those made of the carbon steel, and when finally taken from the boilers they can be sold not only for the market price of steel-tubing scrap, but also at an additional price of 20 cents per pound for their nickel content. Thus it is seen that 30 per cent nickel-steel boiler tubes are really more economical to purchase than carbon-steel boiler tubes.

In addition to marine boilers, high nickel-steel tubes can be used to advantage for stationary boilers, automatic boilers, and locomotive safe ends. It is the higher elastic limit of the 30 per cent nickel-steel boiler tubing that will prevent the leaks that are constantly being formed where the mild carbon-steel tube is used. The leaks are due to the expansion of the fluesheets when heated, which compress the tubes at the points where they pass through the fluesheets, and cause in the case of the mild carbon-steel tube a permanent deformation. This results in the leakage and necessitates the frequent expanding of the tubes. In the high nickel-steel tubes this difficulty is overcome by their higher elastic limit. This deformation and the resulting leakage are especially true of locomotive boilers. For automobile tubular boilers a 23 to 25 per cent nickel-steel tubing is used, each coiled section being made from one long piece of nickel-steel tubing, which, by a special heat treatment, is enabled to withstand this bending without cracking.

Nickel-steel tubing containing 12 per cent of nickel has been used by the French since 1898 in the manufacture of axles, brake beams, and carriage transoms for field artillery wagons, and the desired result in the reduction of weight has been obtained without loss of strength and without stiffness of the wagons. A 5 per cent nickel-steel tubing has been used in the manufacture of bicycles since 1896.

Chromium Steel.

The largest use of chromium is in the manufacture of a ferro-chromium alloy which is used in the manufacture of chrome steel. In the manufacture of armor plate ferro-chrome plays a very important part, and, although it is sometimes used alone for giving toughness and hardness to the armor plate, it is more commonly used in combination with nickel, making a nickel-chromium-steel armor plate. Other uses of chrome steel are in connection with five-ply welded chrome steel and iron plates for burglar-proof vaults, safes, etc., and for castings that are to be subjected to unusually severe service, such as battery shoes and dies, wearing plates for stone crushers, etc. A higher chromium steel which is free from manganese will resist oxidation and the corrosive action of steam, fire, water, etc., to a considerable extent, and these properties make it valuable in the manufacture of boiler tubes. Chromium steel is also used to some extent as a tool steel, but for high-speed tools it is being largely replaced by tungsten steel, which seems to be especially adapted to this purpose.

The percentage of chromium that is used in the chromium steels varies from 2.5 to about 5 per cent and the carbon from 0.8 to 2 per cent. The hardness, toughness and stiffness which are obtained in chromium steel are very essential qualities, and are what make this steel especially beneficial for the manufacture of armor-piercing projectiles as well as of armor plate. For projectiles chromium steel has thus far given better satisfaction than any of the other special steels, and is practically the only steel that is used for this purpose. The value of chromium steel for this purpose is well brought out by Mr. R. A. Hadfield, manager of the Hecla Works, Sheffield, England, who states that a 6-inch armor-piercing shot made by this firm was fired at a 9-inch compound plate, which it perforated unbroken. It was then fired again from the same gun and perforated a second plate of the same thickness, the shot still remaining unbroken.

Tungsten Steel.

Tungsten steel is used to some extent more generally abroad than in the United States, in the manufacture of armor plate and armor-piercing projectiles. For this purpose it is used in combination either with nickel or chromium, or with both of these metals. The use for which tungsten steel seems to be best adapted is in the manufacture of high-speed tools and magnet steels. The property that tungsten imparts to the steel is that of hardening in the air after forging and without recourse to the usual methods of tempering, such as immersion in oil, water, or some special solution. For high-speed tools tungsten steel is especially adapted, as it retains its hardness and cutting edge even at the temperature developed in the use of these high-speed tools. The value of tungsten steel for permanent magnets is on account of it retaining comparatively strong magnetism and of the permanence of this magnetism in the steel. This property makes the tungsten steel particularly desirable in instrument work where the calibration of the instrument depends upon the permanence of the magnet used. For compass needles tungsten steel has been used by W. and L. E. Gurley with entire satisfaction.

Molybdenum.

The use of molybdenum steel continues to increase, and hence there is an increasing demand for the ores of this metal. The main use of ferromolybdenum is in the manufacture of tool steel. The properties which molybdenum gives to steel are very similar to those given by tungsten, the main difference being that it requires a smaller quantity of molybdenum than of tungsten to acquire the same results. Ferromolybdenum is produced, like ferrotungsten, by reducing it from the ore in an electric furnace. There are now two molybdenum-nickel alloys being produced, one of which contains 75 per cent molybdenum and 25 per cent nickel, and the other 50 per cent molybdenum and 50 per cent nickel. Besides these constituents the alloy contains from 2 to 2.5 per cent iron, 1 to 1.5 per cent carbon, and 0.25 to 0.50 per cent

silicon. The molybdenum steel which is made from these alloys is recommended for large cranks and propeller-shaft forgings, for large guns, rifle barrels, and for wiring and for boiler plates. The molybdenum increases the elongation of steel very considerably, and for wire drawing such an increase at a comparatively small cost is important.

Vanadium Steel.

On account of the extremely high price and scarcity of vanadium ores, the metal has thus far been employed very little in the manufacture of ferrovanadium for use in the production of vanadium steel. It is claimed by many that the beneficial properties imparted to steel by vanadium exceed those of any of the other steel hardening metals. These are exaggerated statements, but it may be found that smaller quantities of vanadium will give in some cases the same results that are obtained by comparatively large quantities of the other metals. One property claimed for vanadium steel is that it acquires its maximum of hardness not by sudden cooling, but by annealing at a temperature of from 1,300 to 1,470 degrees F. This property would be particularly advantageous for high-speed tool steel and for points of projectiles. There is, however, at the present time little or no vanadium steel on the market.

Titanium.

The actual commercial value of titanium as a steel-hardening metal has not been thoroughly demonstrated. Experiments have shown that from 0.5 to 3 per cent of titanium increases the transverse strength and the tensile strength of steel to a very remarkable degree. Until the development of the electric furnace it was practically impossible to produce either titanium or an alloy of iron and titanium, but since the introduction of this furnace ferrotitanium can be produced directly from the ores. It is to the manufacture of a special cast iron that ferrotitanium seems to be especially adapted. The titanium in the iron gives greater density to the metal, greatly increases its transverse strength, and gives a harder chill or wearing quality to a wheel made from such an iron. For the manufacture of car wheels it would seem that the titanium iron would be especially useful.

* * *

EXHAUSTING ARRANGEMENT FOR BUFFING WHEELS.

The exhausting arrangement for buffing wheels in the brass shop at Montreal of the Canadian Pacific Railway, here illustrated, was installed by C. H. Gifford & Co., managers of the Philadelphia house of B. F. Sturtevant & Co. The appearance of the shop with the exhausting arrangement in place is indicated by Fig. 2, and the arrangement of the apparatus by Fig. 1; the equipment consists of a 60-inch Sturtevant top horizontal steel plate exhauster designed to run at 720 revolutions per minute, and to discharge into a No. 18 Cyclone collector. Each hood is so designed that the heavy material

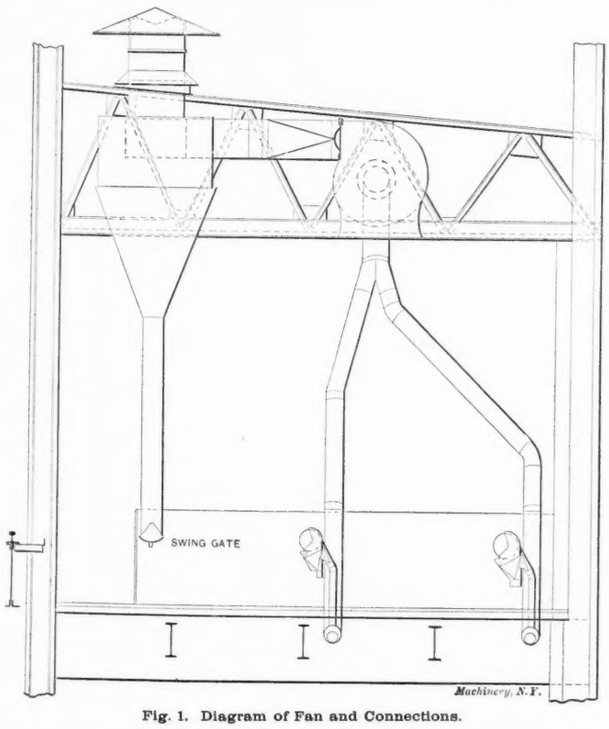


Fig. 1. Diagram of Fan and Connections.

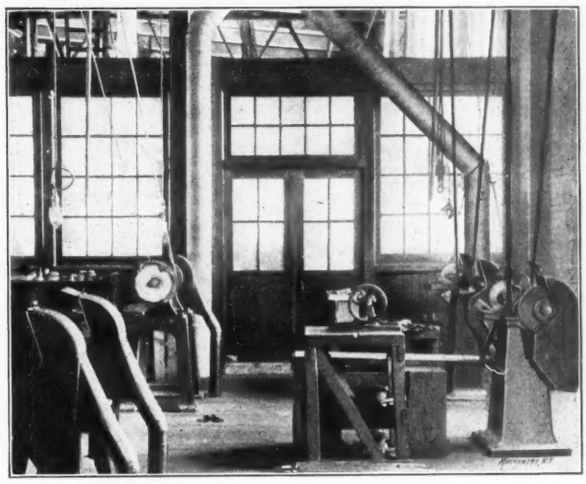


Fig. 2. View of Buffing Room.

drops into the front extension, whence it may be removed, while the air and very light particles are carried into the exhaust system. The horizontal connections to the hoods are beneath the floor. The fan is supported on the roof trusses overhead, as shown in Fig. 1.

* * *

NOTES.

In the paragraph in the last number "Of Historical Interest," which related to an early machine shop in Philadelphia, we gave the name of its proprietor as Thomas Barritt. The name should have been printed Thomas Barnitt, and we make the correction in order to have our published record of this old machine shop correct.

The fifth annual session of the Summer School for Artisans, under the direction of the College of Engineering of the University of Wisconsin, begins June 26th and continues six weeks. Courses of study are in the following subjects: Engines and Boilers, Applied Electricity, Mechanical Drawing and Machine Design, Materials of Construction, Fuels and Lubricants, Shop Work. The entire laboratory and shop equipment of the college is used by the summer students.

The Atlas Engine Works, in common with many other progressive shops, have been conducting tests on various makes of high-speed steel. They find the speeds that they are able to obtain are limited quite as much by the nature of the work as anything else. Their engine shafts come rough turned, so they do not take off as heavy a cut after receiving them at the engine works as is the practice with forgings. On cast iron they believe it more economical to set a pace that can be obtained in nearly every instance, regardless of whether the castings are a little harder than usual, than it is to try variable speeds and leave the work too largely to the judgment of the workman. Work in a plant like this is largely of standard nature and parts are carried through in quantity. Cutting speeds of 50 to 55 feet per minute on band wheels and similar work are satisfactorily attained. Work that formerly took eighteen hours with ordinary tool steel and ordinary methods of day labor now take seven and one-half hours, using high speed steel. Cylinders that were formerly bored in three hours now can be completed in one hour with high-grade steel, improved hoisting apparatus, and proper chucking facilities. They have had excellent results with Novo steel, and have also used Rex steel and Carpenter steel with great satisfaction. They find that Novo steel is readily worked into milling cutters, and on such work have run at speeds of 40 to 45 feet per minute.

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MACHINERY

DESIGN—CONSTRUCTION—OPERATION.

PUBLISHED MONTHLY BY

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We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

MAY, 1905.

PAID CIRCULATION FOR APRIL, 1905,—22,427 COPIES
Including 600 advertisers' copies, as part of their contracts.

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition—$1.00 a year, comprising more than 430 reading pages. The Engineering Edition—$2.00 a year—contains all the matter in the Shop Edition and about 250 pages a year of additional matter, which includes a complete review of mechanical literature, and forty-eight 6 x 9 data sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. RAILWAY MACHINERY, $2.00 a year, is a special edition, including a variety of matter for railway shop work—same size as Engineering and same number of data sheets.

Mr. James Hartness, of the Jones & Lamson Machine Co., Springfield, Vt., in the course of some recent remarks on the subject of the proper holding of work and tools, said that very few of the standard machine tools hold the work and tool with sufficient firmness of control to prevent lateral trembling or quivering. Under correct conditions the action of a heavy chip of steel on properly proportioned tools sometimes wears a slight hollow just back of the edge instead of wearing away the edge. This action, when it has been observed in the engine lathe, happens as a result of a balance of conditions, which includes an amount of clearance of the tool that just equals the feed, and which allows the tool to steady itself by riding on the finished surface. This prevents the quivering which would otherwise have rounded the edge before the chip could have had time to make an impression elsewhere. It is not enough to know that the tool mounting is capable of withstanding heaviest cutting strains without breakage, or even perceptible quiver. We must know that the controlling carriages are short, compact and unaffected by strains varying from light to heavy cuts. Tool holders and carriages are nothing more nor less than springs in equilibrium, and should be of the shortest, stiffest possible design. Chattering frequently occurs because there is no clip or cut large enough to hold all the slack of springing parts. The cure for chattering is frequently more, not less feed.

* * *

THE SLOTTER AS A MACHINE TOOL.

One of the peculiarities of the American machine shop practice is the neglect of the slotter; it is a machine rarely found in other but locomotive and marine engine works, although it is a tool admirably adapted to a large class of work commonly done on the planer and shaper. The design of the slotter is generally credited to James Nasmyth, the inventor of the steam hammer and an improver of machine tools generally; he is said to have developed it about 1836 from the wood mortising machine invented by Maudslay. Nasmyth also developed the shaper, and the slotter may be said to occupy an intermediate position between it and the planer, having the convenience and other good qualities of the former and all the accuracy of the latter. The slotter is a machine on which the work can be set up with the greatest ease, comparing in this respect with the boring mill. It is a machine unequaled for working to a line because of the facility with which the cutting tool can be followed with the eye; moreover, there is no accumulation of chips on the work to interfere with the vision. The work is rigidly presented to the cutting tool, the cutting stresses being directly transmitted through the table to the bed. Plane surfaces at any angle can be machined as readily as at right angles, and gears and other work, which have to be indexed, are handled with facility. The slotter is a tool that is practically indispensable in the railroad shop for handling driving boxes, cutting out valve yokes, slotting false valve seats and bushings, facing the ends of cast iron steam pipes, slotting of frames, etc.; and the features which make it so valuable on this work are of equal worth on many other features found in the average machine shop when the saving of time and accuracy of product are considered. Regarding the latter, it seems peculiar at first glance that the slotter should be found capable of producing accurate plane surfaces when it is so difficult to secure them with the shaper. Both machines have the cutting tool supported by a traveling head or ram, but with an important difference. The shaper has the cutting head mounted directly on the end of the ram, and the cutting stroke usually begins close up to the frame. The greater part of slotter work is done with a cutter-bar mounted in the toolpost of the ram, and projecting a considerable distance below it. In the shaper, the rigidity of support for the tool grows less and less as it travels out over the work, hence the tool is not uniformly supported. In the slotter the deflection of the cutter-bar is practically the same at the beginning of the stroke as at the finish, hence the deflection is uniform and a straight cut is taken throughout. On a great deal of slotting work it is necessary to use a slender tool or punchbar, but the same condition holds, for with the slender bar the deflection, while perhaps excessive, is uniform throughout the stroke.

* * *

Bill and Pete were two apprentices in Jackson's shop about equally matched in mischievous qualities, but with this important difference: When Bill played the time-honored trick on a green man of tying a bag of shavings to his lathe belt just beneath the countershaft cone, so that the moment the shifting lever was thrown over, the contents of the bag would be deposited over the lathe and operator, he did it in the clumsy fashion of getting a ladder and laboriously climbing up to the countershaft. When Pete played the trick he simply watched his chance when the man was absent from the machine and the foreman was looking the other way, tied the bag to the lathe belt, and then hauled it by hand up to the back side of the countershaft cone. It is needless to say that this difference in quickness of thought and grasp of a situation in the matter of playing tricks was equally as marked in after years in the more sober actions of life.

That the qualities, which differentiated Pete and Bill in youth, have a distinct money value is shown by the fact that Bill is now getting $2.25 a day as a journeyman, while Pete gets five times as much, and no lost time, as superintendent of a growing machine company in the West. Is this a reflection on Bill? Not exactly, for all men have their limitations and possibilities. Bill fills a niche and in a way is as indispensable as Pete, but there are more of him. One plans, the other executes; one works with his head, the other with his hands. Head work is useless without hand work, but fewer do it and the demand is greater than the supply. Hence those that supply it get better pay. In other words, it an illustration of the law of supply and demand. If this fact were more generally understood, it should prevent much of the jealousy and hard feeling that too often exists between workmen and their bosses.

* * *

The retirement of Mr. George A. Gray of Cincinnati, Ohio, from active interest in the business which bears his name marks the termination of a mechanical career that is a notable one, although little known outside of his immediate circle. Associated with Mr. Gray in the G. A. Gray Company, are Mr. A. Zuest, Secretary and Treasurer; Mr. H. Erdman, Superintendent, and Mr. Henry Marx, General Agent, who will continue the business on the same lines that have ensured its success in the past.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

The John Fritz medal, which is given according to the rules for the award of the medal "for notable scientific or individual achievement," has just been presented to Lord Kelvin. The fund for the John Fritz medal was established in 1902, and the first medal was presented by the representatives of the four great engineering societies of the United States having the matter in charge, to John Fritz himself.

After two years of poor markets and curtailed production, the steel industry seems to have come into great good times, the present consumption of steel being enormous. Several records for production were broken in March, one of them, a record of 42,387 gross tons of ingots produced by the open hearth furnace plant of the Clairton Steel Co. during the month, establishing a world's record for a 12-furnace plant.

Peat gas as a source of power is being seriously considered by many European engineers. A great difficulty in generating gas from peat is the formation of tar, which has to be separated; this tar carries away much of the heating power of the fuel. In a Deutz producer plant at Oldenburg, tests showed the fuel used, cut peat having 16.5 per cent of moisture, to be only 2.8 pounds per hour for each horse power. In a Koerting producer the peat used per horse power per hour was said to vary from 6.2 pounds, of a heat value of 2,250 British thermal units, to 1.65 pounds with 9,000 heat units per pound. Peat having an average value of 6,300 B. T. U. shows a fuel cost 50 per cent. greater when used in solid form to make steam, than when burned in a gas producer, and the resulting gas utilized in a gas engine.

An interesting paper was read by Mr. Otto Schlik before the Institution of Naval Architects, March, 1904, on the gyroscopic effect of flywheels on board ship, which was fully abstracted in the May, 1904, issue of this journal, Engineering Edition. A press dispatch from Berlin states that the Hamburg-American Line is building a new steamer at the Vulcan Works, Stettin, in which the invention of Mr. Schlik will be incorporated; it is expected that the rotating mass of a large flywheel, mounted in gimbal frames, will reduce the rolling of the vessel in a seaway to a minimum, and thus minimize the provocation to seasickness. It is also pointed out that if the invention proves successful that it will be of great value on battleships as it will greatly increase the stability of gun platforms. The invention has heretofore been tried on models only, and the new vessel will be the first practical demonstration of its utility.

The strength of timber treated with creosote or zinc chloride, as preservatives, was carefully studied by the Government Bureau of Forestry during the St. Louis Exposition. It was found that such reduction of strength as resulted from creosoting was due entirely to the steaming process required in the seasoning, and that it was in nearly direct proportion to the length of time that any steam pressure was applied. In the case of a green loblolly pine the diminution of strength was found to be 25 per cent after a pressure of 20 pounds was applied for ten hours. The treatment with zinc chloride does not seem to reduce the strength of the timber except for the effect of the steaming process. The strength of a timber steamed four hours was the same with or without a treatment with an 8½ per cent solution with zinc chloride. The effect of the creosote seems to be the same in weakening the fiber as of an equal amount of water.

Perhaps one of the most difficult problems in engineering has been the working of the immense deposits of almost pure sulphur which underlie a large area of Calcasieu Parish, Louisiana. These deposits are overlaid with a thick stratum of quicksand which defied all ordinary methods of shaft sinking. After thousands of dollars had been sunk in what seemed like a hopeless enterprise the Standard Oil Company took hold of it and finally hit upon a way of getting the sulphur to the surface, which is as simple as it is ingenious. A number of 4-inch tubes were sunk into the sulphur deposit, and then steam was turned on from a large battery of boilers. The steam was admitted through one or more of the tubes and its heat was sufficient to soften the sulphur so that the pressure forced it out through the other pipes. From these it pours forth in a semi-liquid mass into tanks where it cools and hardens. When cooled it is broken up for shipment. The sulphur obtained from these wells is said to be nearly 98 per cent pure, and is worth $28 a ton at the wells.

Many street railway engineers, according to the *Street Railway Journal*, are of the opinion that something stronger than the chilled cast iron car wheel should be used on interurban lines operating at high speed. The danger of flanges breaking is greatly increased under these conditions, and the steel-tired wheel has been adopted on many roads as a solution of the difficulty. The Hartford Street Railway Company has been using such wheels under cars running under very severe service conditions for about four years, with remarkably good results. Some of these wheels have made mileages of between 100,000 and 200,000 miles each, covering over 200 miles a day, and are still efficient. Their tires have been turned several times, but will permit several more turnings. The Hartford Company has found that the cost of truing is minimized if the tire is turned up in the lathe after every 40,000 or 50,000 miles.

As to the cost, the average cost of a chilled cast iron wheel at Hartford is $6, which, for a service of only 30,000 miles, is 20 cents per thousand miles. Steel tires, as used at Hartford, cost $12, which, with three truings, after each 50,000 miles, and the original application of the tire, at a cost of $1 for each of these operations, makes the gross cost per 1,000 miles only 8 cents. The center of the steel-tired wheel does not require renewing, and should be considered part of the truck equipment.

In a letter to *Graphite*, Mr. John C. Kennedy, purchasing agent of the Nashville, Chattanooga & St. Louis Railway, Nashville, Tenn., refers to an old pair of engines, still running with remarkable smoothness, which have an interesting history: "In 1844 Mr. Polk, of Tennessee, was elected President of the United States. The next Congress passed an act to build a navy yard in the interior of the country, where foreign vessels could not safely reach it. Memphis, Tenn., was selected as the site or place at which to build it. It was built and one double horizontal engine, 14 x 42-inch cylinders, both connected with the main shaft, making 58 strokes per minute, was put in to run the machinery. When the war between the States commenced, the Confederates took these engines to Nashville, and put them into a gun factory. After the fall of Donaldson the Federals took the engines from the works and set them up in the railroad shops, where they were used until 1865. They were then put up at auction by the United States government and were bought by the Nashville, Chattanooga and St. Louis Railway. When the new shops were built they were put in to drive all the machinery in the engine shop, and by rope transmission the boiler shop and blacksmith shop, and are running 23½ hours out of 24, 365 days in the year. Recently while the writer was showing some visitors through the works, he stood a nickel on edge on the bedplate, and it was standing there when they left the engine room."

Portland cement when mixed with water has two properties in regard to hardening which are known by separate names as "setting" and "hardening," the setting being the preliminary stage of hardening. Setting, according to the investigations of Le Chatelier, is due to the formation of a saturated solution of aluminum compounds. It takes place so rapidly

in many instances as to prevent the proper use of the cement. For the purpose of regulating the time of setting, gypsum, sulphate of lime, has been principally used. According to experiments made under the direction of Professor R. C. Carpenter, of Cornell, the retarding effect of gypsum on the setting is considerable, although there seems to be little or no advantage gained in adding more than 2 per cent of the sulphate.

The effect of adding gypsum is only temporary, provided the cement is exposed to the air, and for this reason other retarding materials have been sought for. Experiments made by Candlot would indicate that the addition of from 2 to 4 per cent of slaked lime to a cement containing a small percentage of gypsum which has through the influence of time lost its effect in retarding the setting, will restore the slow setting properties.

Chloride of calcium has been investigated as a retarding material, and it has been shown that with a feeble solution of this chemical the time of setting is greatly reduced, but when the cement is gaged with a concentrated solution of the chloride, it acts in just the opposite manner and tends to increase the rapidity of setting. Candlot, who has made some of these experiments, also states that a feeble solution of chloride of calcium acts very rapidly in slaking lime. A concentrated solution of chloride of calcium hardens Portland cement very rapidly, and causes its tensile strength to quickly reach the maximum, although at the end of a year no deteriorating effects seem to have been caused.

Chloride of calcium is a deliquescent material, which rapidly absorbs water, and it is possible that if ground dry with the cement clinker, if only to the amount of ½ per cent, which seems to be enough to cause the effect, it would cause the material to gather dampness and thus have a bad effect. Investigations are still necessary for determining whether the effect of chloride of calcium added to the cement before grinding is permanent or not.

COMPOSITION OF QUENCHING BATHS FOR TEMPERING CUTTING TOOLS.

The composition of a number of baths for quenching and tempering cutting tools is given by H. Le Chatelier, in an article in *Revue de Metallurgie*. Fused nitrates of potassium and of sodium are too high in temperature for certain cutting tools, as they do not permit of cooling below 220 degrees F. Mixtures of nitrate of potassium and of nitrate of sodium can, however, be employed, and a series of mixtures, fusing at different temperatures, be obtained. He gives the following proportions for these mixtures:

Temperature, Degrees F.	Nitrate of Potassium.	Nitrate of Sodium.
280	0	100
230	20	80
172	40	60
137	55	45
145	60	40
225	80	20
335	100	0

Higher temperatures than 400 degrees F. cannot be obtained with these mixtures. At 400 degrees F. potassium nitrate freely decomposes, whereas in steels where without extreme hardness absolute absence of brittleness is necessary 500 degrees F. to 600 degrees F. are temperatures more suitable. The following bath gives, on fusion, a temperature of 500 degrees F.:

Sodium chloride	1 part
Potassium chloride	1 part
Fused calcium chloride	2 parts
Hydrated barium chloride	1 part
Hydrate strontium chloride	3 parts

For a bath fusing at 700 degrees F., the following mixture may be used:

Hydrated boric acid crystals	1 part
Silver sand	1½ parts
Anhydrous potassium carbonate	1 part
Anhydrous sodium carbonate	1 part

When prolonged treatment is required a little cyanide or charcoal may be added to prevent superficial decarburization; but in view of the strongly cementating action of cyanide, this salt must be used with caution.—*Mechanical Engineer.*

THE GUTERUTH VALVE FOR HIGH-SPEED PUMPS.

For some years past, says *Engineering*, high-speed pumps have been commonly fitted with mechanically-closed valves, and the necessity for this practice has been pretty generally accepted, although in certain cases it has been found that by fitting lighter valves the pump worked just as well after the removal of the closing gear as before. A description is then given of a novel form of spring-closing valve for high-speed pumps, known as the Guteruth valve, which is being introduced in Europe and meeting with success. It consists of a thin sheet of spring steel wound into a spiral spring as indicated in Fig. 1. The splined shaft upon which the spring is strung is also shown in the same cut. A section of a valve seat with the spring valve opened and the liquid flowing through, is

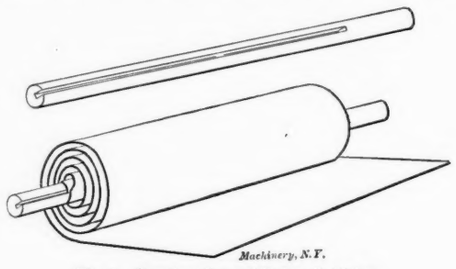


Fig. 1. Construction of Guteruth Valve.

shown in Fig. 2. By inclining the valve seat the valve does not obstruct the flow although it occupies an angular position of only about 30 degrees when open as against 90 degrees, which would be necessary if the seat were at right angles to the axis of flow.

The valve is very light in proportion to the area covered, hence its inertia neither greatly obstructs the flow in lifting from the seat nor causes it to slam when seating. Again its lightness makes it unnecessary to provide any guard to limit the lift. For low pressures the metal strip from which a valve is made is of uniform thickness throughout, but for high pressures it is necessary to thicken the end for the valve proper as indicated in Fig. 2. With properly proportioned apertures in the valve seats, however, a thickness of 1/16 inch has been found ample for the highest pressures met in common service.

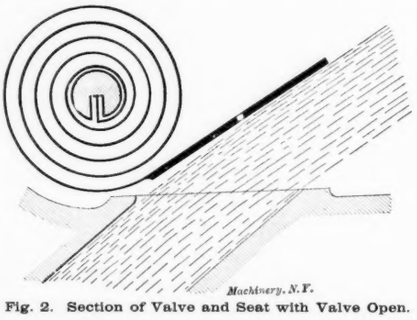


Fig. 2. Section of Valve and Seat with Valve Open.

In Fig. 3 longitudinal and cross-sections are shown of a double-acting pump fitted with these valves. The valves are mounted on a cylindrical casting which is separate from the body of the pump. The castings fit into bored seats, and can be removed with the valves by taking off the heads shown in the cross-section. This pump has a plunger 7.86 inches diameter, and a stroke of 19.7 inches; its capacity is 17,600 cubic feet per hour, against a head of 495 feet. Boiler pumps equipped with the Guteruth valves have been supplied to run at 450 revolutions per minute.

NOTES ON SOLDERING COPPER CONDUCTORS.

Electric Club Journal, January, 1905.

Cleanliness and heat are essentials for a good soldered joint, and must be kept in mind in every job. In making an ordinary spliced joint, the wires are each bared of insulation for a distance of about one inch from the joint and carefully cleaned by the use of sand paper or emery cloth. The emery cloth is preferable because it is so tough and flexible that a rapid scouring of the surface can be made.

The two ends of the cleaned wire are butted together after

slipping over them a carefully cleaned sleeve. The surfaces may be brushed with a solution of sal-ammoniac, or what is preferable, coated with a soldering paste. A solution of resin in alcohol is sometimes employed for this purpose. The joint is now ready for the application of the solder. It is heated by a hot soldering iron or in the flame of a hand-torch until the application of a soldering stick to its surface shows that the solder will readily flow over the cleaned surfaces. Certain precautions must be observed in heating the joint, as, for instance, not to get the surface too hot, as the copper will then oxidize. Neither must the surface be too cold, as the solder will not then readily flow, as a consequence of which the joint may be imperfectly united, or because of frozen drippings, it will present stalactitic points which have to be cut or filed off before tapping the joint. It is absolutely necessary that the soldered joint have a smooth surface, otherwise the insulation will be cut.

If, however, the joint need not have mechanical strength and is only required to be electrically conducting the use of a sleeve may be dispensed with. The wires may then be placed side by side overlapping and wrapped with fine copper wire, about No. 26 in size. The fine wire holds the joint in position. Care should be used in wrapping that the wrapped wire presents no sharp points. Solder is now flowed on as before. After a sufficient amount has been put on to cover the surface, and the interstices of the fine wire are filled, it is advisable to wipe the joint with a cloth just as a plumber does in wiping a joint. This removes any excess of solder and makes the joint smooth on its surface.

If the conductor is two wires in multiple and it is desired to solder it to a similar pair of wires, it is usual to cut one wire of each pair half an inch to an inch shorter than the other and then place the two conductors together. These may be wrapped as above and their soldering presents no difficulty. Obviously, this may be extended to the soldering of any number of conductors in parallel.

It is sometimes necessary to solder a sheet copper strip to a wire in order to provide a flexible lead for wires of large size. After the surfaces are cleaned one end of the copper strip is formed to fit the wire to which it is to be soldered. After fluxing, the soldering operation is performed as usual. If a single copper strip does not provide sufficient conductivity for a wire cable, two or more of them are placed in parallel upon it, in which case difficulty is apt to be experienced from the flowing of solder between the strips.

Solder will always run on hot copper. To obviate this difficulty it is usual to place strips of material between the sheets of copper to prevent their being united by the flowing solder.

Copper wire up to the size of No. 0 may readily be soldered by a soldering iron of the usual size, say an inch and a quarter square. With larger sizes a torch must be used unless one has a pot of hot solder with a couple of ladles, when the hot solder may be poured from the ladle directly on the joint. This can be accomplished by pouring upon the joint and catching the drip in the ladle underneath the joint. If the joint is of such a size that it is not warmed at the first pouring, the lower ladle may be brought over the joint and a second pouring may be made. This process is to be continued until the joint is thoroughly hot, which will be apparent from the fluidity of the molten solder running through it. If a sufficient amount of solder is not retained in the joint, as may happen if the joint is too hot, it may be filled in from a small stick of solder and then wiped as it cools to secure the requisite smoothness.

In soldering one cable to another cable it is usual to interleave the fine wires to a sufficient length and then wrap the whole with fine wire, after which it may be treated in the usual way. When a cable is to be inserted in a sleeve or a terminal plug it may be dipped in the soldering fluid and then plunged into molten solder. The plug in which the cable may be placed can be tinned in the same manner. The receptacle of the plug is now filled about half full of solder, when the tinned cable may be plunged into it. The parts should be solidly in position and remain undisturbed until cooling has taken place.

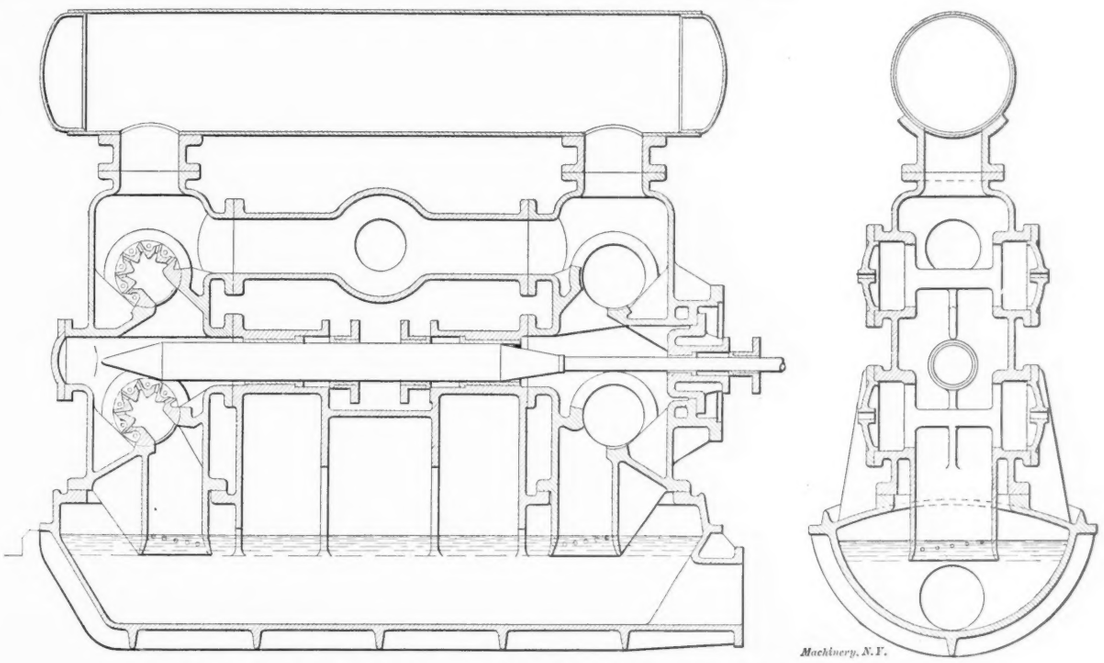


Fig. 3. Longitudinal and Cross Sections of Double-acting Pump Fitted with Guteruth Valves.

WATER-TUBE BOILERS FOR GERMAN CRUISERS.

Der praktische Maschinen-Konstrukteur, December 8, 1904.

The water-tube boiler after many years of trial seems to have finally established itself permanently in the naval marine. Just what final form it will assume is, as yet, uncertain.

Among the latest vessels to be fitted with this type of boiler are the German cruisers of the classes known as C and D. The form used is shown in the illustration on the next page. In the outer nest of tubes *I*, those of the cluster *i* are bent out so as to form a chamber. The gases of combustion first pass through the central nest *III* as usual, and then curving through an S-shaped path traverse the outer nest, *I*, in such a way as to again mingle with the air. Should it so happen that the fire is not burning evenly over the whole surface of the grates, the hot gases will be thoroughly mixed together in this chamber. The two nests of tubes are not brought close together in this case, but there is a narrow space *h* left between them, which serves as a means of kindling the unburned gases. In addition to this, fresh air is admitted through the front and back walls of the boiler into the combustion and fire chambers.

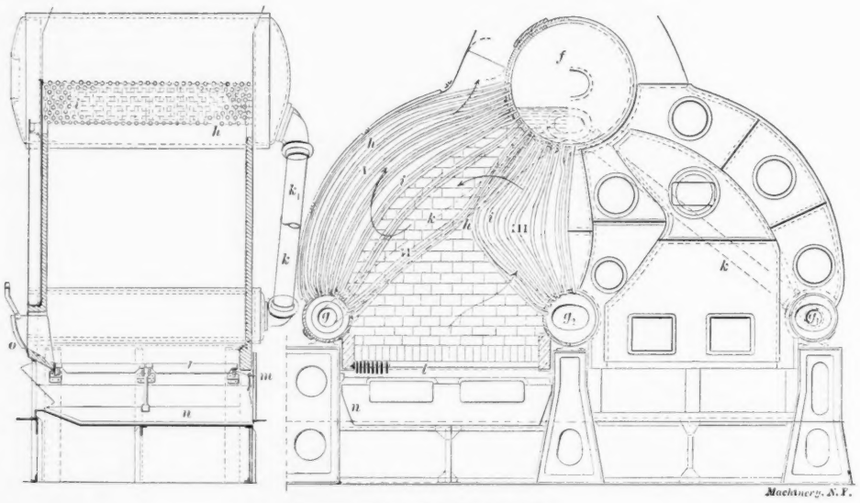
As a consequence of this rational method of conducting the

combustion the production of smoke is reduced to a minimum, a matter of great importance in naval work. Great clouds of smoke emitted from the stack are a great hindrance to the gunners on board, besides serving to make the ship visible to the enemy at great distances.

The combustion chamber also serves as a reservoir of heat, where the varying temperatures of the gases are equalized. The result is that the stresses imposed in service in this boiler are not as severe as in the ordinary water-tube boiler.

A further improvement in this boiler as compared with the standard type is to be found in the three bottom shells g, g_2 and g_1, the two outer of which are connected to the main shell by large tubes that are beyond the reach and influence of the fire gases. Here there are two tubes k and k_1 connecting g and g_1 respectively with the main shell f, while g_2 is connected direct by the central nest *III*.

In some of the later boilers this outside connection is done away with, as it has been found that the circulation is satisfactory and efficient without it. Observations have also shown that the best results are obtained when coal is burned on the grates of these boilers at the rate of about 50 pounds per square foot per hour. G. L. F.



German Water Tube Marine Boiler.

PRACTICAL INVESTIGATIONS IN THE GAS TURBINE PROBLEM.

Dr. Chas. E. Lucke, in the Engineering Magazine, April, 1905.

The receiving of a jet of fluid and bringing it to rest is the function of the rotating part of every turbine, and work is done by this member only because it can bring to rest the jet of fluid once formed with a given velocity. The velocity is given to any fluid or gas by forcing it to flow through an orifice or nozzle from a place of high pressure to one of low pressure. For an incompressible fluid such as water there is no change in density and hence no expansion of the mass with the change of pressure. If the fluid be a perfect gas, however, it will change density with the pressure change, and suffer an expansion in addition to the phenomena present in constant density fluids. Such expansion through a nozzle is termed "free expansion." In perfect gases, then, in addition to the velocity due to pressure drop with density constant, as in the case of liquids, there is also a velocity due to change of density as the result of pressure and temperature change. In the case of a vapor such as steam, free expansion adds an additional phenomenon, that of partial condensation or possible superheat. In the case of a vapor, therefore, there are in addition to the first two velocities named a third increment of velocity due to this change of state. These phenomena may be divided into purely mechanical action and thermal action. As the kinetic energy of the resulting jet is due to all three velocity increments for a unit mass flowing, that part of the resultant kinetic energy that is due to free expansion of a perfect gas or vapor is also dependent on the thermal characteristics of the fluid. This part of the kinetic energy of the jet is measured by the amount of heat that has been given up by the fluid to give the mass the velocity increment due to free expansion.

The turbine engine using expanding fluids such as steam or a perfect gas depends for its possibilities of output and efficiency on first, a mechanical action in the jet, and second, a thermal action, of which the latter may be absent. The turbine may be useless if the maximum amount of original energy of the fluid is not first converted into kinetic energy of the jet. The mechanism so far used for conversion of the original potential energy of the fluid into kinetic energy of the jet is the nozzle; practically all nozzles in use were designed on some assumption of the phenomena taking place in free expansion, because there is not in existence sufficient experimentally verified information to permit of a more positive method.

The classification of gas turbines is particularly applied to those turbines using the products of combustion from a fuel and air previously compressed. There are three elements to the system of any of these: *a*, a compression pump for air and fuel; *b*, a receiver for the fuel and air compressed and a pressure combustion chamber to convert the fuel and air into hot gas; *c*, the turbine proper to use the hot gases. The efficiency of the system will depend primarily on the efficiency of conversion of the heat of the hot gases from the fire to kinetic energy of these gases after the expansion. For this conversion to be good, the temperature of the hot gases must be lowered in acquiring velocity. Expansion in a cylinder behind a piston is termed "balanced" expansion, because the pressure of the gas is always balanced by the piston resistance and the mass is practically at rest. It is well known that such balanced resistance will cool the gases, and by this cooling heat is converted into work. It has been taken for granted by many that by a free expansion in a nozzle, the temperature drop would be the same as for expansion behind a piston; experiments to determine how to produce equivalent results by free and balanced expansion have, however, been far less numerous than the reiteration of statements that such equivalence must exist.

A few experimental facts may be shown to bear upon this case. One style of ice machine compresses air, cools it after compression to the temperature of whatever water is available, and subsequently expands the air in cylinders, the exhaust from the cylinders for even moderate initial pressures being cold enough to freeze water. The cooling resulting from this balanced expansion gives results which agree very well with those theoretically computed on an assumed law. Inventors have, however, sought to substitute for the second or expanding cylinder in the above process, free expansion in a simple nozzle, assuming equivalence of results of free and balanced expansion. This attempt has met with total failure, the air after passing the nozzle being only a few degrees cooler than before passing. This may be explained in part by the fact that the air in the system loses velocity by

impact, and so suffers a temperature rise, but this does not account for the whole difference observed, because water cannot be made to freeze on the nozzle itself, with air that easily freezes water on the exhaust pipe of the air cylinder operating under balanced expansion.

A thermometer held in the stream of air issuing from an open valve or nozzle on a compressed air main will show for even a pressure drop of 100 pounds per square inch only 3 or 4 degrees temperature change. To eliminate possible errors due to impact of the air on the thermometer, the author measured the temperature of the air when moving at the maximum velocity by means of a thermal couple made of fine wire, stretched axially along the jet. These tests show a maximum temperature drop of only 30 degrees Fahr. for air expanding through a steam turbine nozzle from 100 pound pressure down to the atmosphere. This result is only 12 per cent. of the temperature drop that would have resulted in balanced expansion without gain or loss of heat.

The experiments of Tripler and Linde in liquefying air likewise show a lack of equivalence between balanced and free expansion. Air compressed to 2,000 or 3,000 pounds per square inch was cooled by water, and then some of the air freely expanded through a hole, the discharge passing around the pipe feeding the hole. This was intended to cool the air in the pipe below its critical temperature for liquefication under the high pressure used, but the results were very different from the case of balanced expansion. The temperature drop through the nozzle being only about ¼ degree F. per atmosphere-pressure drop, according to one report. The results for the Linde process are here shown, the initial pressure being 220 atmospheres.

Temperature approaching the Nozzle.	Actual Temperature Drop through Nozzle.
+ 30 deg. F.	35 deg. F.
0 deg. F.	65 deg. F.
— 30 deg. F.	80 deg. F.
— 60 deg. F.	96 deg. F.
— 100 deg. F.	112 deg. F.
— 150 deg. F.	135 deg. F.

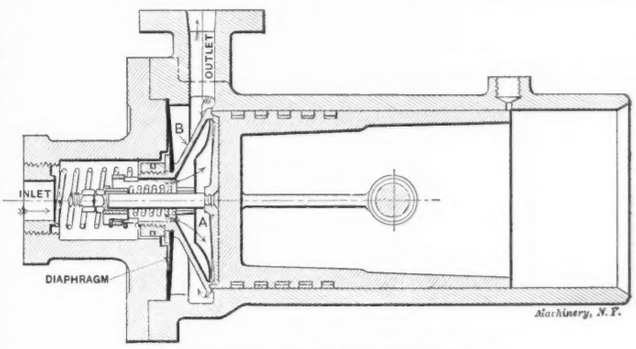
Unless, by an increase of knowledge of free expansion of perfect gases, it becomes possible to produce results equivalent to those obtained with balanced expansion, there cannot be the same amount of heat transformed into work by the gas turbine engine as by the cylinder-and-piston gas engine.

In conclusion, the situation may be summed up by saying that so far no work has been done that warrants any assumption of equivalence, and the difference is so great that the pure gas turbine, provided with the simple nozzles used by steam turbines, is a failure commercially, and can never rise above this until some method has been found to make results by free expansion more nearly equal to those obtained in cylinders.

AIR COMPRESSOR WITH MINIMUM CLEARANCE SPACE.

The two features which most largely affect the economy of air compressors are the means for cooling the air as it compresses, and the amount of clearance space between the piston and cylinder heads. In a recent issue, *Engineering* describes the Kryszat air compressor, built in Great Britain by Shaffer & Budenberg, Manchester, in which the clearance space is reduced to practically zero. Therefore the volumetric efficiency is in effect very nearly 100 per cent, *i. e.*, the volume of free air compressed in a given time should equal the cubic contents of the cylinders, multiplied by the number of working strokes. In the ordinary type of air compressor having more or less clearance space, the compressed air in this space expands as the piston retreats on the induction stroke, and thus reduces the volume of free air which can be drawn in. When the compression is high, the reduction in volume of free air drawn in becomes very serious; with very high compression it may become such a percentage of the stroke that the compressor is totally inefficient. Hence the necessity for very small clearances—the smaller the better.

The Kryszat air compressor is single-acting and built very much on the lines of a small gas engine. Air is drawn in through the center of the cylinder cover, and discharged through the vertical branch near the back end of the cylinder. The arrangement of the valves is seen in the figure, a vertical section through the cylinder and cover. In this illustration *A* represents the suction valve and *B* the delivery valve. The latter is carried by a circular diaphragm of sheet metal held in the counterbore of the cylinder by the cover. The seating of the delivery valve is formed on the inner end of the cylinder barrel, and the valve is held to its seat by the larger helical spring shown, the pressure of which can be adjusted by the screwed collar in the suction orifice. The suction valve is in the form of a flat disk, the seat of which is on the face of the delivery valve, to which it is held by the smaller helical spring.



Air Compressor with Minimum Clearance Space.

When the piston starts on its forward stroke, the suction valve is lifted, and free air enters the cover and passes into the cylinder through the center of the delivery valve. When, on the return stroke, the air is sufficiently compressed, the two valves move back together, and the air escapes into the annular space surrounding the discharge valve and emerges by the vertical outlet. Owing to the large diameter of the valves, a very slight lift is necessary to give free passage to the air when entering and leaving the cylinder, and it will be seen that the clearance may be reduced until the piston actually comes in contact with the surface of the suction valve without danger. Owing to the small lift of the valves and the short stroke of the piston they can be run at about 30 revolutions per minute.

EXPERIMENTS WITH CUTTING TOOLS AND APPLICATION TO LATHE DESIGN.

Institution of Mechanical Engineers, February 13, 1905.

Professor J. T. Nicolson, of the Municipal Technical School of Manchester, England, is well known for the tests on the performances of cutting tools which he has made during the last year or so, his "Experiments with a Lathe Tool Dynamometer" having been widely reported in the technical press. In a lecture on the "Results of Force Measurements with Cutting Tools and the Application to Lathe Design," delivered before the Institution of Mechanical Engineers, February 13th, and based largely on these experiments, he suggested that the lathe bed as usually made is badly designed. According to Professor Nicolson the lathe bed has been designed mainly with a view to withstand forces tending to bend it, whereas torsional forces are possibly in some cases of greater importance than bending. Experiments carried out by Professor Nicolson have resulted in much data on the side, vertical and end pressures on cutting tools. As stated by our English contemporary, "Engineering," such data are hardly necessary in the case of machine tools worked with the old carbon steel tools, because experience has already led to quite satisfactory proportions for all such tools. Where, however, machines are to be operated with the high speed steels, Professor Nicolson's Manchester experiments should aid in bridging over that period in their manufacture in which the designs are to a large degree tentative. Some points brought out in the lecture, as abstracted from *Engineering*, are as follows:

Professor Nicolson's experiments have shown that with a cutting angle of 80 degrees for cast iron (tool angle 75 degrees) and of 70 degrees for soft steel, the horse power needed at the point of the tool is about 2 horse power per pound of chips per minute. To this must, of course, be added the power needed to drive the tool light, which, in the case of light cuts, is a large proportion of the whole, and is the main

reason why a heavy cut and a slow speed are more economical of power than a light cut at a higher one. Where the chips come off in the same shape and fashion, and the tools are equally sharp, the net horse power expended in the actual cutting operation is practically the same per pound of metal removed whether a light or a heavy cut is taken. The power to be provided will, of course, depend upon the heaviest cut which the tool is to take. This will generally be heavier in a turret lathe than in a common lathe operating on work of the same diameter.

For the common lathe Professor Nicolson finds that practice seems to agree well with the rule that the heaviest cut is 1-40th of the height of the centers in depth, and the traverse is 1-160th of the same height. The area cut is then $\frac{h^2}{6400}$, where h is the height of the centers. The speed of cutting may be

$$v = \frac{1}{a} + 15 \text{ for soft steel,}$$

and

$$v = \frac{1}{4a} + 20 \text{ for cast iron.}$$

Here v is the cutting speed in feet per minute and a is the area of cut in square inches.

The force needed to produce a chip of given area is not, it should be mentioned, a function of this area only, but is dependent upon three factors in addition, which Professor Nicolson calls the bluntness effect, the angle effect, and the "crowding" effect. The tool in practice is never ideally sharp, but is curved at the point to a radius which, if small, is always finite. The block of metal just over this rounded point is carried up with the tool bodily, and is thus subject to a shearing strain, failure taking place when the angle through which it is strained reaches a limit which differs with different materials. The work thus done varies proportionately to the square of the radius of the cutting edge. In very tough materials, such as copper, the shear angle at which failure occurs is very large, hence for satisfactory work the radius of the cutting edge must be small, or, in other words, keener tools should be used on a material like copper than on steel, and keener on steel than on cast iron.

A difference in the cutting angle of the tool also has a marked effect upon the power required to remove a given weight of chips. It does not, however, pay to adopt for the tools that angle at which the cutting force required is least, since the tool lasts better with a much larger cutting angle. The best cutting angles in practice appear to be 70 degrees for steel and 80 degrees for cast iron. These angles are the angles between the upper surface of the tool and the tangent to the work cut, so that the actual tool angles are about 5 degrees less. A peculiar feature which has been noted with high-speed steel is the fact that the wear is not at the point of the tool, but at some distance back from it. Indeed, it appears that the force on the tool is not greatest at the point where the metal is separated, but at some distance further back, where the shaving is curled up. The consequence is that the very hot shaving obtained in using high-speed steel is pressed on to the tool with maximum force some distance back from the point, and as it is moving rapidly, the combination of the high temperature and friction wears a groove in the tool, the latter failing as soon as this groove reaches the cutting edge. With small tool angles this soon occurs, but with greater angles much more metal must be eroded before the cutting edge is reached by the groove. The "crowding" effect arises from the fact that the chips, in coming off, swell both in width and thickness. Hence, if a tool is cutting in anything but a single plane, as is necessarily the case with a round-nosed tool, the portion of the resultant chip coming off at one point interferes with the motion of that coming off at other points, with the result that the parts are crowded into each other, so that more power is needed to remove a given weight of metal than would otherwise be required. An extreme case is that of a parting-tool, where, as is well known, much lighter cuts must be taken than in surfacing work.

Another point touched on by Professor Nicolson was the proper proportioning of the step-pulley and change gears. Unless special arrangements are made, only a finite number of speed changes can be provided for. The highest speed should be that enabling the tool to give its maximum possible output on the smallest diameter which it is profitable to turn in the lathe, and this, according to Professor Nicolson, may be a diameter of one-eighth the height of centers. The lowest speed should be such that the maximum output is also attained on the maximum diameter which can be swung on the lathe. The number of intermediate changes of speed which should be provided for is mainly a commercial question. From a consideration of the cost of each additional change of speed, and the loss arising from the impossibility of running the lathe at the speed most appropriate to every diameter, Professor Nicolson considers that the geometric ratio between successive speeds should be 1.08 in the case of a 6-inch lathe and 1.24 in the case of a 72-inch lathe. That is to say, if R be the maximum of revolutions per minute provided for and r the smallest, then, in the case of a 6-inch lathe, $R = r\ (1.08)^n$ inches, where $n + 1$ is the total number of speed changes.

MACHINISTS' PROTRACTOR.

Zeitschrift fur Werkzeugmaschinen und Werkzeuge, December 25, 1904, page 123.

The small instrument shown in the accompanying engraving is a useful one for the machinist. It can be used not only as a level but a means of measuring an angular variation from the vertical and horizontal. It can be folded so as to go in the pocket. Two applications are shown in Figs. 1 and 2.

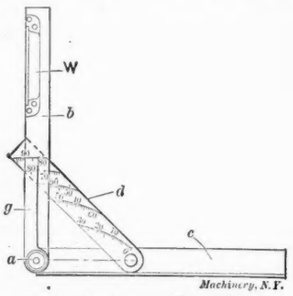


Fig. 1. Protractor Measuring a Right Angle.

As will be seen from the illustrations, the instrument consists of two bars b and c connected by a pivotal joint. To the bar c there is also pivoted a shorter bar d. Upon the latter a number of arcs are drawn with the same radius from the pivotal point a, the length of this radius being $a\,f$, as indicated on arm b in Fig. 2. Further, a shorter arm g, of length equal to the radius, is pivoted at a to b. This serves to measure any angle greater than 90 degrees, as shown in Fig. 2.

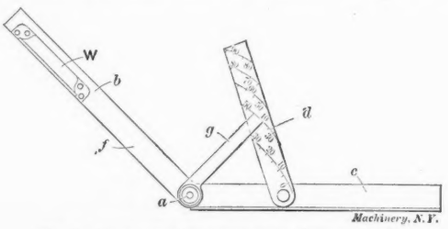


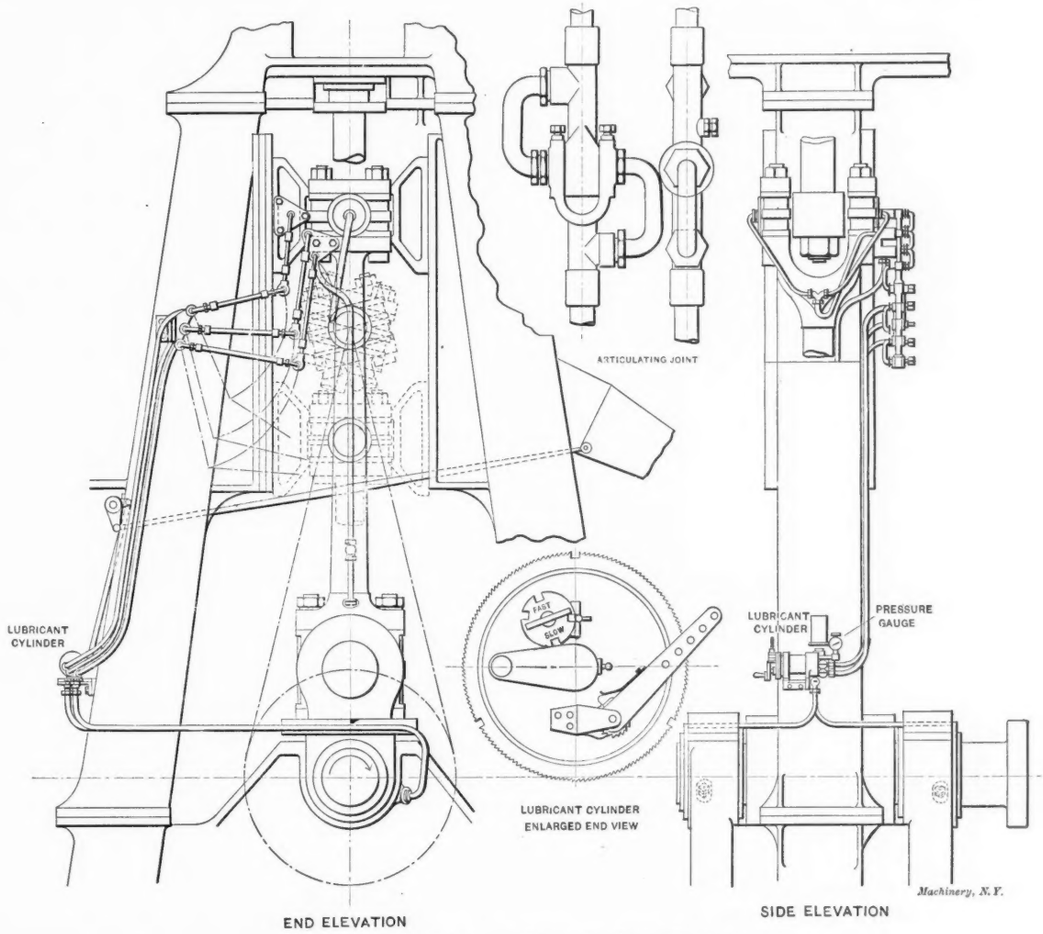
Fig. 2. Protractor Measuring an Obtuse Angle.

There is also a spirit level on the arm b at W in order that any variations from a horizontal may be measured. Angles are measured by opening the instrument and noting the graduation coinciding with the point f. For angles greater than 90 deg., the readings are taken from the arm g.

FORCED GREASE LUBRICATION SYSTEM.

In the December, 1904, issue of the *Indian and Eastern Engineer*, a forced grease lubrication system for marine engines was illustrated, which is of considerable interest at the present in view of the improvements being made in machinery lubrication generally. As will be seen from the illustration, the grease is forced by a piston and cylinder through a system of distributing pipes to the various bearings, including not only those which are fixed like the crankshaft, but those having a reciprocating and revolving motion like the crosshead and crank-pin. These pipes are fitted with a system of articulating joints, which permits them to follow the motion of the crosshead, etc., and carry the grease to them under some pressure. The piston of the grease cylinder is operated by a ratchet arm connected to some part of the valve motion from which it gets an oscillating motion. The

manufacturers of this system of grease lubrication, Thompson Bros., 155 Fenchurch Street, London, E. C., claim a very material saving in the cost of lubrication of marine engines by this system as compared with the use of oil or grease applied by oilers in the usual manner. It has been applied to vessels aggregating 100,000 horse power, principally in service to the Orient. Figures published for one vessel, tonnage not given, which with oil lubrication had required 681 gallons of oil for a round trip of four months, at a cost of approximately $250 for oil alone, show that with the forced grease lubrication, the expense for oil and grease (oil still being used on some of the bearings) was reduced to $200 and the number of oilers reduced from six to three, whose wages for the round trip amounted to $390, making the total saving about $440.



Forced Grease Lubrication System for Marine Engines.

STEAM ENGINE RESEARCH.

First Report of the Committee of the Institution of Mechanical Engineers, March 17, 1905.

At the meeting of the Institution of Mechanical Engineers, March 17, the first report of the Steam Engine Research Committee was presented to the Institution by Professor Capper. This report, in which are incorporated the results of over 100 tests extending over six years on jacketed and unjacketed cylinders, was particularly directed to the determination of leakage through the slide valve and piston into the exhaust, and also to research upon the subjects of condensation and re-evaporation upon the cylinder walls.

The engine used in the experiments was a horizontal compound, having cylinders of 6½ inches and 11¼ inches diameter, by 14 inches stroke, arranged side by side, the cranks being placed at right angles. Each cylinder was separately jacketed on the barrel and ends, the supply and drain on the ends being separate from that on the barrel. Each cylinder was fitted with a Meyer expansion valve, adjustable by hand, so that the cut-off could be varied for each cylinder between ¼ and ⅝ of the stroke. Either cylinder could be arranged as a simple engine by a grid valve on admission and exhaust sides and the engine could be made single acting by blocking either of the Meyer plates. A first series of trials was made with the engine arranged as a single cylinder, high pressure, non-condensing jacketed engine; the second series being the same, except that it was made without jackets. Before beginning the tests it was determined that the variables should be temperature and speed, cut-off and other conditions being kept constant.

It is evident that any steam leaking through the slide valve or piston of a steam engine to the exhaust will not be shown on the expansion curve of the indicator diagram, and that any other leakage through either piston or valve will affect the diagram so as to modify the conclusions drawn without taking such leakage into account. Messrs. Callendar and Nicolson have shown that such leakage may be considerable. The analysis made in the present experiments confirms the conclusions at which they arrived, that without making allowance for this leakage no correct determination can be made of the relative weight of steam and moisture present in the cylinder. In this connection it was found that the leakage under given conditions was less when the cylinder barrel was warmed by the jacket than when the barrel was cold.

In making the leakage tests to be described, the high pressure cylinder with the ordinary valve was used, the steam ports being blocked. Steam was admitted to the steam chest, and the engine being driven by external power, the steam escaping into the exhaust was measured. The leakage under working conditions was closely approximated by jacketing the cylinder barrel and ends.

In all except the slowest, or 50 revolution, trials, a distinct reduction in leakage is noted when the sliding surfaces are well lubricated, over the corresponding leakage with scant lubrication. This effect is not, however, constant or very large: such a reduction was observed, however, in so many individual trials as to definitely prove that where the oil film is continuous and uniform, leakage is appreciably reduced. The curves given in Fig. 1 show this clearly, although the

reduction diminishes with increase of pressure. It may be noted that where in one instance the lubrication failed on the curve for the well-lubricated jacketed trials, the leakage at once rose above that for scant lubrication. The leakage, as would be expected, rises with an increase of pressure between steam chest and exhaust. The leakage increases approximately as the pressure where the valve is stationary in mid-position, but when the engine is running the leakage does not increase so rapidly as the pressure, and the higher the speed the larger does this divergence become. The conclusion is reached by the

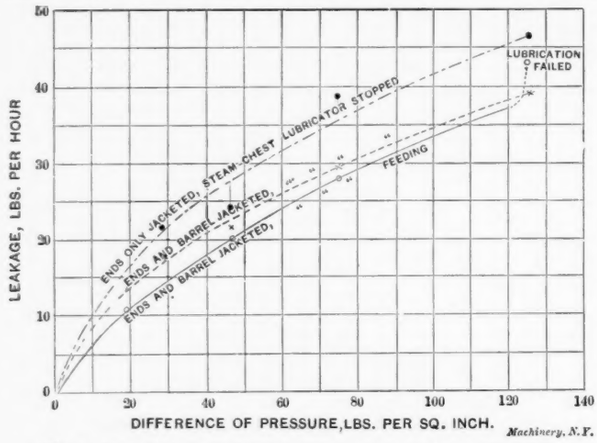

LEAKAGE, LBS. PER HOUR
DIFFERENCE OF PRESSURE, LBS. PER SQ. INCH.
LUBRICATION FAILED
ENDS ONLY JACKETED, STEAM CHEST LUBRICATOR STOPPED
ENDS AND BARREL JACKETED, " " "
ENDS AND BARREL JACKETED, " " FEEDING
Machinery, N.Y.

Fig. 1. Curves showing Leakage through Slide Valve to Exhaust.

author that much of the leakage must be in the form of moisture condensed on the valve face and re-evaporated as it passes over into the exhaust. Experiments were made as bearing upon the above, particularly to determine what effect wire-drawing and the consequent superheating of the steam previous to its entering the steam chest would have upon leakage, and a reduction of about 25 per cent. in the leakage was shown for the amount of wire-drawing used in the experiment.

The leakage is consistently less at the high speeds than at the low where the cylinder walls are jacketed and the surfaces lubricated. The difference between the leakage when the engine is stationary with the valve in mid-position, and when it is running, indicates that the amount of overlap and its variation has an important effect upon the leakage. Although the leakage is not directly proportional to the pressure for all speeds, and it is doubtful whether it is exactly inversely proportional to the overlap, yet these assumptions are sufficiently accurate to enable an approximate correction for leakage to be made by their use.

The leakage through the piston was measured by blocking the port at one end of the cylinder and running the engine single-acting. Cards of the working and blocked ends were also taken. It was found that the piston leak was independent of revolutions per minute, and was proportionate to the admission pressure and area of indicator diagram on the working side of the piston. The piston leak was found at its worst to be less than 2 per cent. of the steam consumption of the engine.

The general conclusions which have been drawn from these experiments may be summarized as follows:

Firstly, leakage through the slide-valve has been quantitatively determined under defined conditions, and has been shown to be nearly independent of speed of sliding surface and proportional to difference of pressure between the two sides of the valve. Further, it has been shown that the assumption that the leakage is inversely as the overlap of the valve is at least in the main well founded. And further that with well fitted valves the leakage may amount to over 20 per cent. of the steam entering the cylinder and is rarely less than 4 per cent.

Secondly, it has been shown that for an unjacketed engine with a given ratio of expansion initial condensation, expressed as a percentage of the steam in the cylinder, *diminishes* with increase of initial temperature, while the total condensation per stroke *increases* with such temperature increase.

This, though suggested by Messrs. Callendar and Nicolson's researches, has never previously been demonstrated with clearness, as, if leakage is not allowed for, the results are obscured and even reversed, and the conclusions arrived at without leakage allowance are therefore unreliable.

Thirdly, it appears from the results here obtained that the re-evaporation for a given ratio of expansion is as great and sometimes greater without jackets than with them. This shows very clearly that the regenerative action of the cylinder walls with a given ratio of expansion is largely independent of their mean temperature. No quantitative analysis of re-evaporation is possible where leakage is not taken into account, as without the necessary allowance results would be largely illusory.

Fourthly, it is possible from the results obtained to show the temperature when for any speed of revolution with a given rate of expansion the jackets will become unnecessary or wasteful. If the heat units per I.H.P. per minute required by the unjacketed engine for each speed of the series be plotted either on an initial pressure or a mean effective pressure base the points for each speed will be found to lie on four curves, which become closer and closer to one another as the speed increases, and all converge to a point as pressure or temperature increases. If the heat consumption for the jacketed series be likewise plotted, it will be found that the points for the different speeds at each pressure lie irregularly round a point, their exact position being determined by the accidentally slight variations of the conditions of each trial. A fair curve through the means of these points will lie below the corresponding curves for the unjacketed trials, but if the heat absorbed in the jackets be included, the resultant curve cuts the unjacketed curves at points which for each speed indicate the temperature and pressure at which the jackets cease to be economical. Such curves are shown, plotted to a base representing initial pressure, in Fig. 2. It will be seen that the full black line, which is the resultant mean for the jacketed trials, cuts both the 250 and the 200-revolution unjacketed curves within the temperatures and pressures included within the scope of the present experiments, and the temperatures and pressures

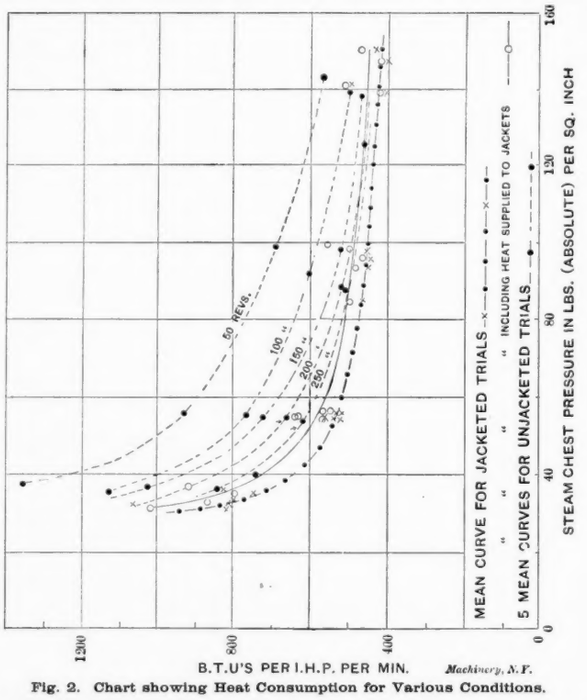

MEAN CURVE FOR JACKETED TRIALS
" " " INCLUDING HEAT SUPPLIED TO JACKETS
5 MEAN CURVES FOR UNJACKETED TRIALS
50 REVS.
100 "
150 "
200 "
250 "
STEAM CHEST PRESSURE IN LBS. (ABSOLUTE) PER SQ. INCH
B.T.U'S PER I.H.P. PER MIN.
Machinery, N.Y.

Fig. 2. Chart showing Heat Consumption for Various Conditions.

where the 150, 100 and even the 50-revolution curves would cut, can very closely be predicted. As far as the author is aware, this is the first time when an exact determination for a given engine and ratio of expansion of this point has been diagramatically shown.

In the discussion of this paper Mr. Longridge said that he would like to point out that the statement that the leakage varied according to the difference in pressure was not exactly in accordance with the results of the experiments. He said he thought that it would be found that instead of being proportional to the difference in pressure, the leakages were more nearly proportional to the square roots of the differences in pressure.

THE FORMS AND RELATIVE ADVANTAGES OF TEETH IN GEARS AS USED IN ROLLING MILLS.*

There are two curves chiefly used in designing the shape of gear teeth, namely, the cycloid and the involute. Their uses for this purpose dates back to the first quarter of the last century. Teeth shaped according to cycloidal curves are best for wear, but unless the pitch circles of a pair of wheels so designed meet exactly, the teeth will chase each other until they create their own shape. The advantage of cycloidal teeth over involutes lies in this, that in the former concave and convex surfaces come in contact, which affords a larger area of contact upon which to distribute the pressure than with involute teeth in which all surfaces are convex. With this form the area of contact is reduced to a line, and consequently the teeth are much more subject to abrasion than if the pressure were more distributed. However, the involutes, too, have an advantage over the cycloidals, namely, that in this form of teeth the pitch circles of a pair of wheels may be apart or overlap and yet not affect the good working of the wheels.

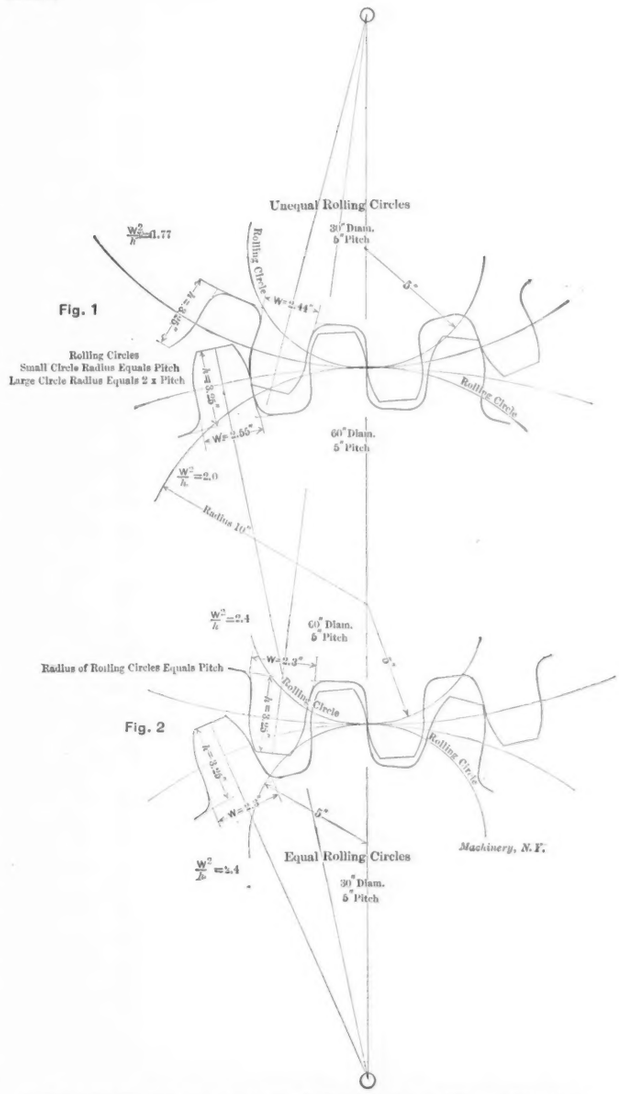
In well designed wheels the angular velocity must be uniform throughout the whole revolution of each pair of wheels. The teeth should be of proper strength at the root, and they should run without much noise.

Cycloidal Teeth.

The curves for these teeth are described by rolling a circle once on the convex and once on the concave side of the pitch circle. The curve thus produced on the convex side of the pitch circle forms the portion of the tooth projecting from the pitch circle outward, and is called "epicycloid," whereas the curve produced inside of the pitch circle forms the lower portion of the tooth, and is called "hypocycloid." The circles employed in developing these curves are called the rolling circles. The diameter of the rolling circle is of great influence upon the shape and strength of the tooth it produces. The smaller the diameter of the rolling circle, in proportion to the pitch circle, the thicker will be the tooth at its root, which means also greater transverse strength, and *vice versa*, the larger the rolling circle, the narrower and weaker will be the root of the tooth. But, wherever practicable, large rolling circles should be chosen because gears so designed have more teeth in simultaneous mesh, run more quietly, and the line of pressure in the middle position of two teeth in touch is nearer to a tangent at that point, than with a rolling circle of small diameter. The largest circle that may be used is one whose diameter is equal to the radius of the wheel, for in this instance the profile of the part of the tooth between the pitch circle and the root circle becomes a straight line, running radially from the pitch line to the center of the wheel, and if the rolling circle were made still larger, then that part of the tooth would be hollowed out and thereby weakened. In wheels that have little power to transmit, and especially if they run fast, the diameter of the rolling circle may be anything less than the radius of the pitch circle, but when the capacity to transmit power is the essential requirement, then the diameter of the rolling circle should be selected with due regard to strength, first and secondarily to quiet running. If a pair of wheels are of considerably different diameters, it is advisable to use rolling circles whose diameters are about in proportion to those of the wheels. However, this may be done only with wheels for some special machine, for neither of these wheels would work satisfactorily with one of the same pitch, but designed with the aid of some other rolling circle. Shops that follow the manufacture of wheels, as their specialty, make all teeth according to a standard rolling circle, whose radius is either a certain fixed fraction or multiple of the pitch, or equals the pitch. Gears so designed will work together no matter from what part of the world they come.

Gears with few teeth, for instance nine, must be designed with a small circle, otherwise the base of the tooth will be so narrow as to impair its strength. Professor Reuleux, who is a recognized authority on gearing, recommends seven-eighths of the pitch as radius of the rolling circles, and this ratio is adopted by many mechanical engineers and also by specialists in the manufacture of gears.

Fig. 1 shows a pair of wheels of respectively 30 and 60 inches diameter and 5-inch pitch. The teeth are cycloidal, but made by two different rolling circles whose radii are 5 and 10 inches, or one equals the pitch, and the other is twice the pitch. In using different rolling circles, they are employed in this manner, that the larger one describes the root portion of the flank of the large wheel, and the upper portion of the flank of the small wheel, and conversely the small circle describes the root portion of the tooth of the small wheel and the top portion of the tooth of the large wheel. By examining this pair of wheels we notice first of all, that there are three pairs of teeth in mesh.



In Fig. 1 the Teeth are produced by Rolling Circles of different Diameters for the Faces and Flanks; in Fig. 2 a single Rolling Circle is used.

Fig. 2 represents the same pair of wheels, as far as diameters of pitch circles and the pitch are concerned, but the teeth of both wheels were produced with one and the same rolling circle. Comparing these two pairs of wheels we find that in the second pair there is only one pair of teeth in mesh, although the pitch and diameters are the same as in Fig. 1. This demonstrates the influence the diameter of the rolling circle has upon the shape as well as on the other properties of teeth. The wheels having three pairs of teeth in mesh must run smoother, hence with less noise and less wear than those with only one pair of teeth in mesh.

Fig. 3 shows three teeth on a 30-inch diameter wheel. Each tooth is of a different pitch, namely 3½, 4 and 5 inches respectively. The rolling circles in each case have radii equal to the pitch. In examining these teeth as to their individual transverse strength, we find that the 4-inch pitch tooth is equal

* Paper read by Mr. Samuel Diescher, before the Mechanical Section of the Engineers Society of Western Pennsylvania, April 5, 1904.

in strength to the 5-inch pitch tooth. At first glance this looks odd, but is quite natural, for the coarser the pitch, the fewer teeth are in a circumference, and the more will they taper from the pitch circle toward the root circle, subject to the same rule as stones in an arch, which is, the broader the stone on top, the greater is the angle of taper. With the coarseness of the pitch grows also the height of the tooth. The transverse strength of a tooth grows with the square of its thickness at the root and inversely with its height, or bending moment. For this reason if in any particular instance the wheel diameter

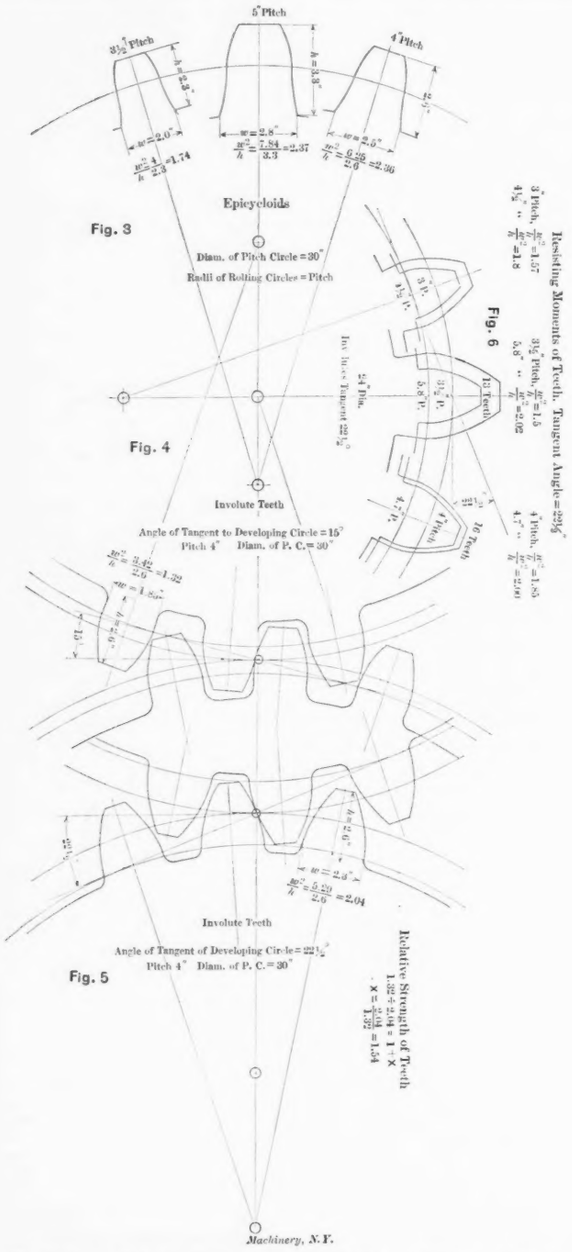

5" Pitch
3½" Pitch
4" Pitch
Epicycloids
Fig. 3
Diam. of Pitch Circle = 30"
Radii of Rolling Circles = Pitch
Fig. 6
Resisting Moments of Teeth, Tangent Angle = 22½°
Fig. 4
Involute Teeth
Angle of Tangent to Developing Circle = 15°
Pitch 4" Diam. of P. C. = 30"
Involute Teeth
Angle of Tangent of Developing Circle = 22½°
Pitch 4" Diam. of P. C. = 30"
Fig. 5
Relative Strength of Teeth
Machinery, N.Y.

Fig. 3, shows Relative Strength of Teeth of Different Pitch, but with same Rolling Circle.

Fig. 4, a pair of Wheels with Involute Teeth.

Fig. 5 shows Teeth laid out with Path of Contact making Angles of 15 and 22 1-2 Degrees respectively, for the two sets of Teeth.

is given and a tooth is to be determined to give the greatest strength of tooth with the greatest number of teeth in the wheel, it will be necessary to figure it out, and not to rely upon the thickness of the tooth in the pitch lines, for that is deceiving.

Fig. 4 represents a pair of wheels with involute teeth. The wheel diameters are both 30 inches and the pitch is 4 inches. The angle of the tangent of the developing circle is 15 degrees. This angle is almost universally adopted as the standard tangent angle for developing circles, and it has precisely the same influence upon the harmonious working of involute teeth as the rolling circle in relation to cycloidal teeth. By examining these teeth we find here, too, that only one pair of teeth is in mesh. Of course, there are positions of the wheels in which two pairs will mesh, but only for a short interval. However, for comparison, we must note that all of the wheels here shown are represented as standing in a middle position, that is, a line drawn through the two wheel centers passes also through the point of contact between one pair of teeth. As to the comparative transverse strength of cycloidal and involute teeth of the same pitch, 4-inch, in wheels of the same diameter, 30 inches, we find by a calculation that the strength of the cycloidal tooth is to that of the involute tooth as 2.36 is to 1.5.

There are occasions when wheels of especial strength of teeth are required, for instance, in rolling mill gearing, particularly in mill pinions. The latter are usually designed with very coarse pitch with the aim of insuring great strength. For the reason of heavy wear in the bearings and journals of mill pinions and the contingent parting of the pitch circles from each other, the involute teeth are more satisfactory than those of cycloidal form, but in order to impart to those teeth greater strength than standard teeth would have, the angle of the tangent to the developing circle is made greater than 15 degrees. Thus in some of the larger plants about this city, an angle of 22½ degrees is adopted as the standard for mill pinions, and at the Carnegie Mills, as much as 28 degrees.

In Fig. 5 we see a pair of 30-inch wheels with 4-inch pitch, and 22½ degrees angle of tangent. By comparison we see that these teeth are much stronger than the same teeth at a 15-degree angle, though every other dimension is the same in both cases. We find also that here too, only one pair of teeth is in mesh. Furthermore, we find that in Fig. 5 the line of pressure through the point of contact is much less normal to the line drawn through the wheel centers than in Fig. 4, and therefore a greater pressure is exerted toward the journals and bearings than in the former instance. Concerning the strength it is to be said that according to calculation, the strength of tooth in Fig. 4 is to that in Fig. 5, as 1.5 is to 2.3, or the tooth in Fig. 5 is by 53 per cent stronger than that in Fig. 4.

In Fig. 6 we see 6 involute teeth in a 24-inch diameter wheel, and angle of tangent of 22½ degrees. These teeth are of different pitches, namely, 3, 3.5, 4, 4.5, 4.71 and 5.8 inches. The latter pitch corresponds to 13 teeth, the standard number adopted for all mill pinions in one of our largest manufacturing plants in Greater Pittsburg (National Tube Works, Mckeesport), whether their diameters are large or small. It is difficult to see why any fixed number of teeth should be adopted for all sizes of wheels.

The pitch 4.71 inches is introduced here for comparison because it gives 16 teeth against 13 of the 5.8 inches pitch. A wheel with 16 teeth runs smoother than one with 13 teeth. The strength is determined by the quotient derived by dividing the square of the thickness of root by the height of the tooth. Accordingly the relative strength of these teeth is as follows:

3-inch pitch, 1.57; 3.5-inch pitch, 1.50; 4-inch pitch, 1.85; 4.5-inch pitch, 1.80; 4.71-inch pitch, 2.0; 5.8-inch pitch, 2.02. Hence 4.5-inch is to 5.8-inch as 1.8 to 2.0 and 4.71-inch is to 5.8-inch as 2.0 to 2.0.

The pitch of 4.71-inch gives 16 teeth of the same strength as the teeth of 5.8-inch pitch, of which there are only 13 teeth in the wheel of the same diameter as that of 16 teeth.

* * *

A prominent electrical dealer from Texas recently visited St. Louis, and took the opportunity to look through the Emerson Electric Mfg. Co.'s factory. After being duly impressed by the activities of the machine shop, the press rooms, the assembling department, and the testing force, he came to a stop before the machine of a workman winding a small direct current motor armature. The machine was started, the coil wound, tied, pushed in and wedged, the leads brought out, and the operation repeated several times; still his interest did not flag. At last the visitor pulled out his watch. "One minute and thirty-five seconds per coil," he thoughtfully announced. "And in Texas we get $12.50 for rewinding an armature like that!"

LETTERS UPON PRACTICAL SUBJECTS.

DIES FOR MAKING TIN NOZZLES.

Editor MACHINERY:

In this article is shown a set of dies for the production of nozzles for tin cans of large sizes used to ship liquids. The dies are of the combination type used in single action presses and do from one to three operations at one stroke of the press. From 12,000 to 15,000 pieces of finished work can be turned out per day from these dies according to the speed of the operator.

The first die, Fig. 2, is composed of five principal parts: *A* is a gray iron bolster plate made to separate at the line *a-b* so the die can be readily taken apart for repairs. *B* is

Fig. 1

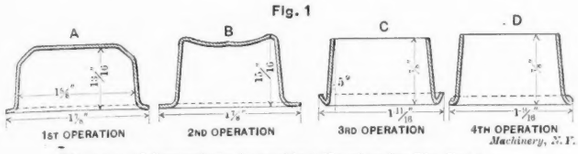


Diagram of Operations in making Nozzles for Tin Cans.

the "cut edge" set into the top plate and held down by three flat-head screws (not shown). *C* is the center block set into the lower plate of the bolster and also held in place by flat-head screws, not shown. *D* is the pressure ring or blank-holder which rests on three pins (one shown) which in turn are supported by the washer *E*, which rests on the rubber spring surrounding the stud *F*, and held in place by another washer and nut (not shown) with which to regulate the pressure while drawing the shell. *G* is the punch and drawing die combined, the outside diameter of which is fitted to the cut-edge *B*. The inside diameter is fitted to the center block *C* plus twice the thickness of metal. *H* is a forming pad made to fit the top of the center block *C*. It forms the top of the shell at the end of the stroke and also serves as a knock-out for the shells.

In operation the tools are set into an inclined press. The punch coming in contact with the cut-edge *B*, cuts the blank, which is held by the pressure ring *D* against the end of the punch *G*, but as punch *G* continues down the blank is drawn over the center block *C*; and as the punch ascends the stem *I* in the top of the punch shank comes into contact with a bar in the press pushing the pad *H* down, and the shell represented at *A*, Fig. 1, slides off back of the press.

Fig. 3 shows the second operation or redrawing tools. *A* is the bolster plate, *B* is the drawing ring, supported by pins and a rubber spring, the same as in Fig. 2. The center block in this die is tapered and the punch *F* is also bored out tapering to fit it. The pad in punch *F* is of peculiar shape, as will be noticed and will be explained later. The shell is placed

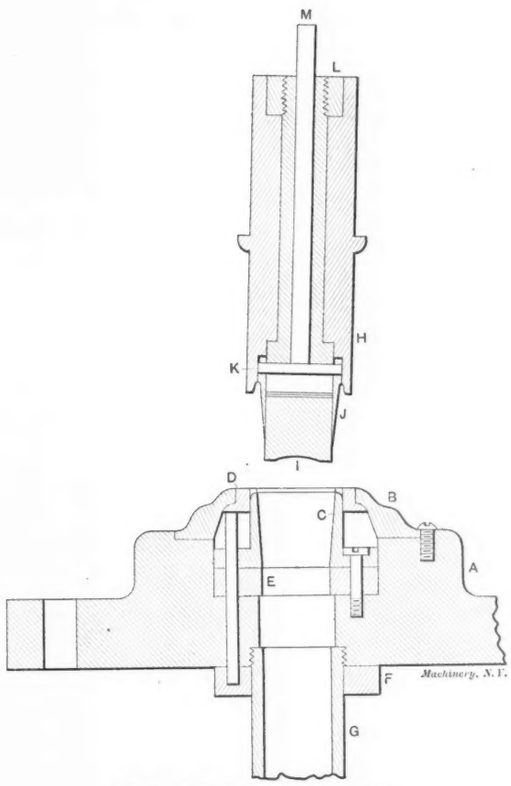


Fig. 4. Tools for the Third Operation.

on the drawing ring and the punch as it descends draws it down and compresses it to the shape of the center block *C*. The shell is knocked out on the up stroke by the stem *H*, same as in the first operation and the drawn piece looks like *B*, Fig. 1.

Fig. 4 shows the tools for the third operation, which really consists of three operations. *A* is the bolster plate of the die; *B*, the trimming die; *C*, the center block; *D*, the drawing ring; *E*, the lower die; *F*, washer; *G*, tube through which the bottom of the nozzle passes after being punched out. These bottoms are used for roofing shells for fastening bar paper in place on roofs, etc., so that in the process we really make two articles at once. These tools are used in an inclined press. As the punch comes down punch *I* cuts the bottom out, and at the same time punch *H* trims the lap edge; as it con-

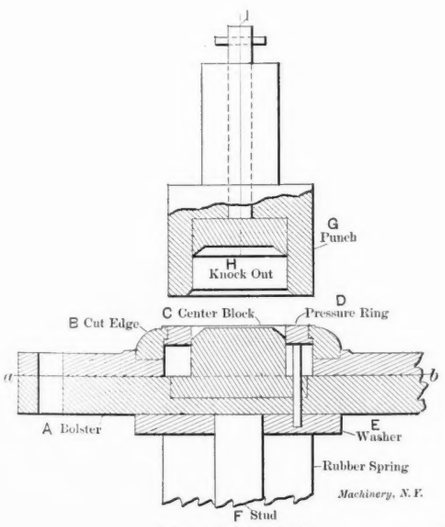


Fig. 2. The First Die.

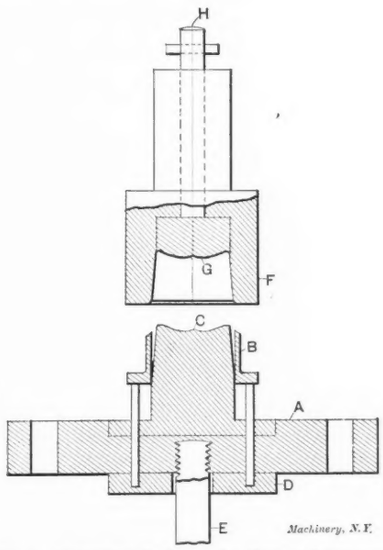


Fig. 3. Redrawing Tools for the Second Operation.

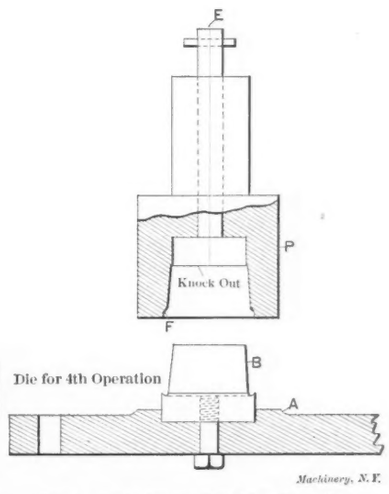


Fig. 5. Tools for the Finishing Operation.

tinues on down it presses the shell over the edge of the center block *C*. As the punch ascends the knock-out bar comes in contact with the pin *M*, carrying the stripper *J* down by the cross-pin *K* and ejecting the nozzle in the shape of *C*, Fig. 1.

Fig. 5 represents the tools for the fourth and finishing operation. It consists of a simple punch and die, yet much depends on these tools, for the nozzles all have to be of an exact size on the finished edge to receive a sealing cap and this cap when closed on has to be watertight. The die consists of a bolster-plate *A* and a die-block *B*, made of tool steel, hardened and tempered. The punch is also hardened and tempered and ground out to gage. The tools are set in the press, the nozzle is slipped on the die-block. The punch *D* in coming down passes over the work until the edge turned up on *C*, Fig. 1, comes in contact with the shoulder *F* on the inside of the punch. As the punch continues on down this edge is curled over and pressed down to the shape of *D*, Fig. 1. As the punch rises the shell is knocked out by the knock-out stem same as in all the other dies.

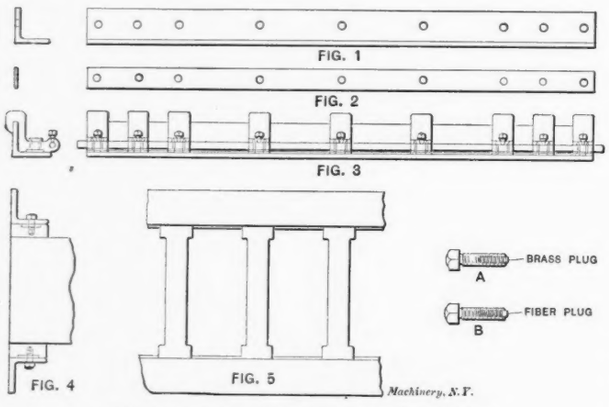
These dies are "all round" dies, so they are not so hard to make as would be the case if they were of an irregular shape.

At the same time I have met men who seem to think that it does not require any *good* tools to produce a tin can, but my opinion is they would change their minds if they had to produce some of the tools themselves, for the tools require the utmost accuracy in points of construction, besides tin is a very peculiar metal to handle in dies. PRACTICAL.

JIG FOR DRILLING ANGLE AND STRAP IRON.

Editor MACHINERY:

The inclosed drawing represents a method of drilling angle and strap iron which gives most satisfactory results when the quantity of work to be done does not warrant the use of a punch and die. The pieces to be drilled are used as the frames for mounting the cast-iron resistance plates of a field regulating rheostat. Each plate is fastened to the frame by the holes tapped in the four lugs which are cast with a recess to receive the strap iron and over this the angle iron as shown in the assembled sketch, Fig. 4. As the capacity of the rheostat may be increased by adding more resistance plates, it was found necessary in the design of the drilling jig to make provision for drilling six different lengths of angle iron with the corresponding different layout of holes. The jig itself is shown in two views in Fig. 3 in position for drilling. The pieces which fit over the angle iron and hold the bushings which locate the holes are made of cast iron in the shape shown in the end view of Fig. 3. To facilitate setting them the required distances



Details of an Adjustable Drill Jig for Long Strips.

apart they were finished exactly one inch wide. They were securely held in this position by means of the setscrews bearing on the long bar of cold rolled shafting. These same pieces were used for drilling all lengths of angle iron by varying the length of the round iron bar which holds them. The recess milled across the bottom of each of these small jigs was for the reception of the ⅛-inch strap iron which was laid on the angle iron and drilled through at the same time. In this respect it is curious to notice how the best intentions of the designer and toolmaker are sometimes defeated by the ignorance or carelessness of the operators using the jigs. It is an actual fact that about sixty of these frames were drilled, first the angle iron and afterward the strap iron, whereas it had been expressly provided that both should be drilled together. To prevent the jig from moving along while the holes were being drilled the angle iron, strap iron and jig were held together with a cap screw and nut after drilling the end hole. Beside the saving shown in the drilling operation the cost sheets showed a saving of from 15 to 25 per cent in the cost of assembling the plates, thus giving us the benefit of quite an economy over the older method of laying out by hand and drilling to a center punch mark.

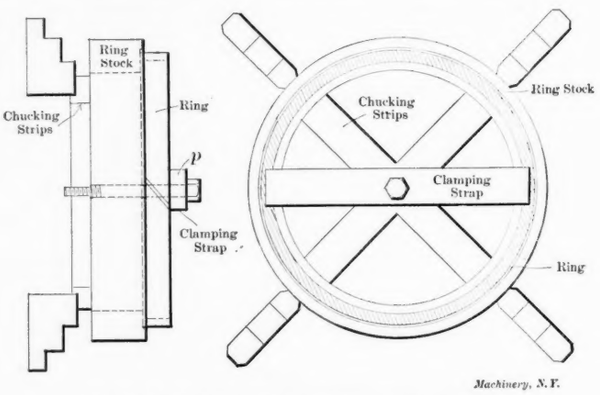
A word of explanation is necessary regarding the use of setscrews on this jig. This was found to be the only objectionable feature and while it must be considered as a necessary evil still in this case the injurious effect of the screws on the shaft was minimized by driving a piece of brass rod into a hole drilled in the end of the screw, as shown at *A*. By protecting the point of the screw in this fashion it may be used in many places where otherwise it could not be allowed. When, for instance, a setscrew bears against slate, marble or any soft material a tip of red fiber screwed into the end, as shown at *B*, answers the purpose better than brass. Because of the shrinkage it is difficult to maintain a permanent driving fit in the fiber and it must therefore be screwed in. As the brass and fiber are fastened to the screws they may be taken out without the necessity of fishing for the small separate piece of protecting material usually used. H. J. BACHMANN.

New York.

RIG FOR RE-TURNING PISTON RINGS.

Editor MACHINERY:

I have seen several ingenious devices in MACHINERY for re-turning piston rings to make them fit the bore of the cylinder. The only objections I have ever found with them was that they were only applicable to a certain diameter of ring; and for a shop which has only a few rings of various sizes to turn, the cost hardly warrants the making of a device unless it is cheap and can be made quickly without any special castings. For such work I have used the following kink with success:



Device for Re-turning Piston Rings of Various Sizes.

After cutting off the last ring, turn a shoulder in the remnant of ring stock 1-64 inch larger in diameter than the bore of the cylinder and 1-32 inch deep. These dimensions will vary with the diameter and stiffness of the ring, but will be found to be about right for an eight-inch bore. Drill and tap the chucking strips on the ring stock for a capscrew.

The rings should then have a piece cut out in the usual manner until they will just slip in under the shoulder turned in the ring stock, with the ends coming together. A cap screw and a clamping strap to clamp the ring in the recess in the ring stock complete the rig. With this rig the rings may be turned to fit the bore of the cylinder, as far as the ring stock will permit. The smaller unfinished portion of the ring can be quickly filed off. If the ring stock have no chucking strips to tap for the cap screw the clamping strap may be bolted to the chuck. STANLEY GOULD.

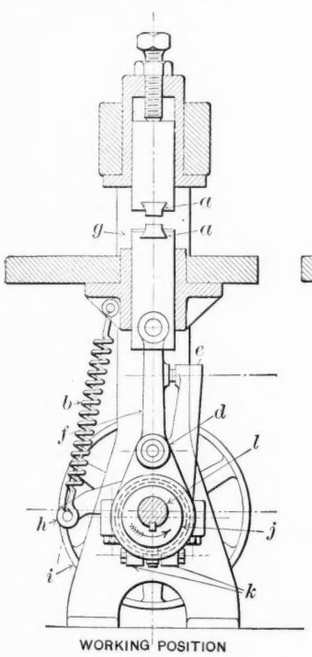
Los Angeles, Cal.

AN INGENIOUS MECHANICAL MOVEMENT.

Editor MACHINERY:

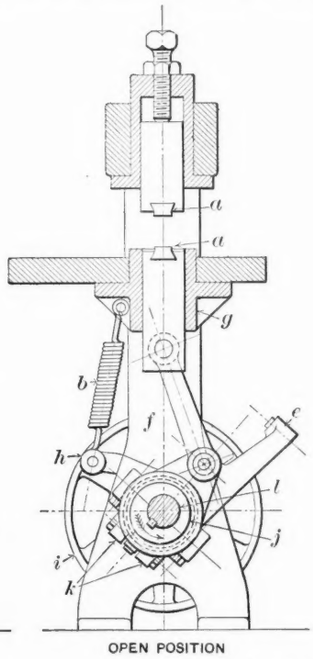
During a recent visit to a firm engaged in a branch of the leather business, the writer noticed a machine which made use of a very interesting mechanical movement, new to him at least. In operation the machine gives the product a series of powerful squeezes, and then opens up the dies to allow the removal and insertion of the work. Figs. 1 and 2 show the working and open positions respectively of the mechanism which performs this duty.

The ram *g* which carries one of the two dies, *a*, is reciprocated by the eccentric *j*, which is keyed to the shaft *l*. This shaft turns in the direction shown by the arrow, and is driven by tight and loose pulleys at *i*. The upper half of the eccentric strap is pivoted to the connecting rod at *d*, and carries an arm *h* to which is hitched the long spring *b*. If there were nothing to prevent it, the spring would evidently tend to pull the joint *d* over as shown in Fig. 2. In this position, with the belt on the loose pulley, the machine is ready to receive the work; *k* and *k* are the lugs of a leather band friction, bearing on an extension of the eccentric surface, and shown in dotted lines behind the eccentric strap. A finger screwed to the lower half of the strap and projecting between the lugs serves to keep the brake in position. If the machine be now started by throwing the belt onto the tight pulley, the brake grips the eccentric with sufficient force to overcome the slight tension of spring *b*, and joint *d* is moved back again to a central position bringing the parts into the position shown in Fig. 1, where buffer *e* has reached its seat on the connecting rod.



WORKING POSITION

Fig. 1.



OPEN POSITION

Machinery, N.Y.

Fig. 2.

The shaft continuing to turn, brake *n* slips on its seat, and the eccentric gives the desired movement to the ram. When the operation is completed, the belt is slipped to the loose pulley, and spring *b* turns the shaft, eccentric, and strap backward until the machine is again open, with the ram lowered to allow a change of work.

The writer does not know if this device is patented, or patentable, but it may prove suggestive to someone who has a similar problem to solve.

RALPH E. FLANDERS.

Malden, Mass.

FORMULA FOR PLANING THREAD TOOLS.

Editor MACHINERY:

I give herewith diagram and formulas for thread tools, with special reference to those used in a Pratt & Whitney thread tool holder, same holder being the one considered the best and mostly used by leading firms. As the planing of thread tools used in above holder is rather particular and quite confusing to those not familiar with same, I have given formulas by means of which the angles, to which the planer or shaper-head should be set, can easily be figured. The formulas will be readily understood from the diagram, but a word may be needed in explanation of "the leading" and "the following" side of the thread tool, the former being that side of the tool first entering the work when a thread is cut.

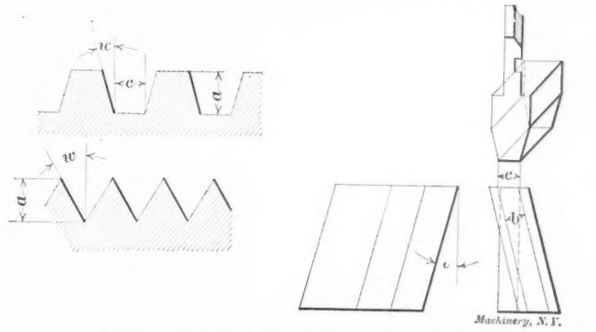


Diagram Illustrating the Planing of Thread Tools.

1. Tool with Side Clearance.

a = depth of thread.
b = width of flat on offset tool.
c = actual width of flat.
d = outside diameter of screw.
v = clearance angle.
w = ½ angle of thread.
y = angle of helix.
x = normal angle (to which to set planer head, when planing tool on side).

$$\tan y = \frac{\text{Lead}}{(d - a)\ 3.1416}$$

$$\tan x = \frac{\cos y \pm (\cot w \times \sin v \times \sin y)}{\cot w \times \cos v}$$

Use + for leading side and — for following side.

For Acme (29°) thread and 15° clearance angle, the formula can, for all practical purposes, be written:

$$\tan x = \frac{\cos y \pm \sin y}{3.735}$$

The width of flat on the offset tool is figured from the formula: $b = c \times \cos y$.

2. Tool without Side Clearance.

If the tool has no side clearance, the angle of helix can be considered = 0°, and above formula reduces itself to: $\tan x = \frac{\tan w}{\cos v}$;

for 60° screw thread, United States standard, the formula has this appearance: $\tan x = \frac{\tan 30°}{\cos 15°} = .5977$; $x = 30°\ 52'$.

In this latter case the width of flat of tool (c) remains unchanged.

It will be noticed that formulas are given first for "tools with side clearance" and second for "tools without side clearance"; of course any thread tool ought to be given a side clearance, the amount of which depends on the angle of helix of thread to be cut, but on account of the small angle of helix on fine pitch threads, the necessity of using a tool with side clearance in such cases is reduced to a minimum, and can for practical reasons be dispensed with.

A. L. VALENTINE.

Hartford, Conn.

A NOVEL DRILL PRESS ATTACHMENT.

Editor MACHINERY:

The piece of work illustrated in the two views, Fig. 1, was of tool steel cut from the bar and milled all over to exceedingly accurate dimensions, after which it was further machined at *C* to the shape shown. It was necessary that the point *C* have a radius of exactly 3-16 inch with its largest diameter exactly ⅜ inch. To facilitate the accomplishment of this somewhat difficult machining rapidly and cheaply, and at the same time to insure the production of perfectly interchangeable parts

through the operation, the fixture illustrated in Figs. 2, 3, 4 and 5 was designed and used. The four views of the jig comprise a plan, Fig. 2, a vertical cross section, Fig. 3, a longitudinal section, Fig. 4, and an end view, Fig. 5, and they should make the construction of the various parts and their working functions when assembled quite clear.

D is a cast-iron base block upon which, at one end, a machine steel block *E* is located and fastened by two flat head screws *G* and dowels *F*. A square channel or clearance way is let through at *H*, to allow of locating suitable stops and entering the work beneath the cutting tool. *I* is a stop or end locating piece against which the work *C* is located. *J* is a side support for the work with a section worked out to a radius equal to that of the outside diameter of the cutting tool. *N* is the positive-side banking piece fastened to *D* by the screws *O*. *K* is the clamping side piece which has a slotted hole permitting of limited movement under the shoulder screw *L*. *Q* is the eccentric clamping lever swinging on shoulder screw *P*, which is used to force and hold the clamp *K* tightly against the work. *R* and *S* form parts of the adjustable stop for the end of the work to locate against. The means used for clamping the work down into its seat in the jig are very simple and effective. By simply pulling the eccentric lever *M*, swinging on shoulder screw *U*, upward, the work is secured; by forcing it down, the work is instantly released and may be pulled out through the clearance channel or notch in the lever shown at *V* in Fig. 3.

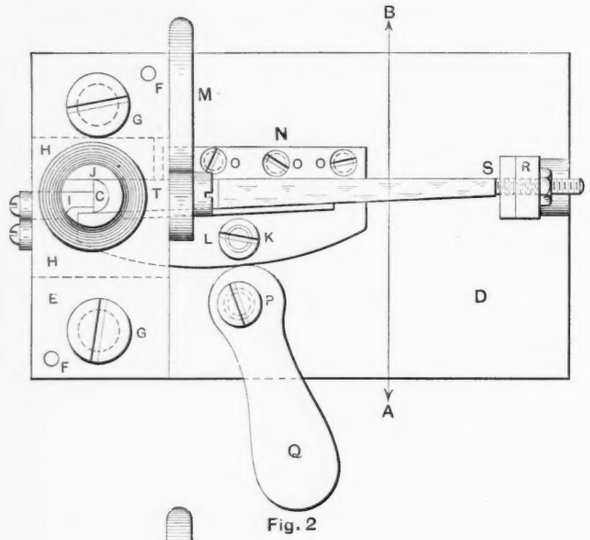


Fig. 2

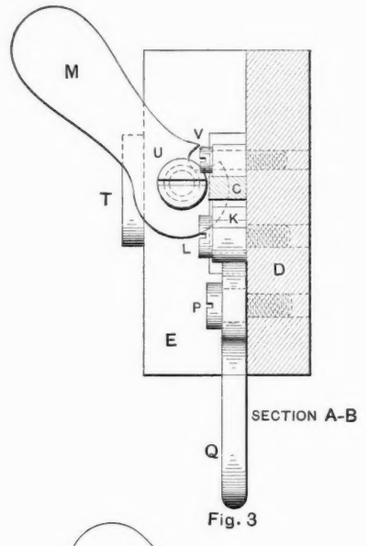


Fig. 3

Fig. 1

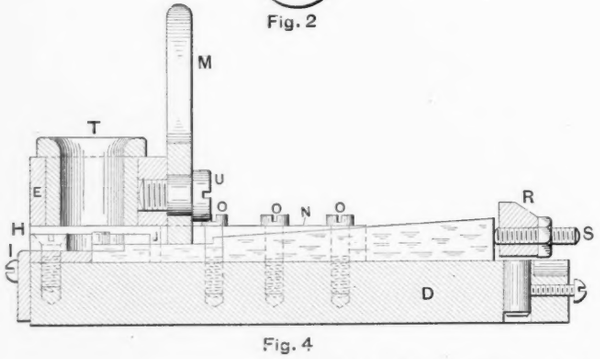


Fig. 4

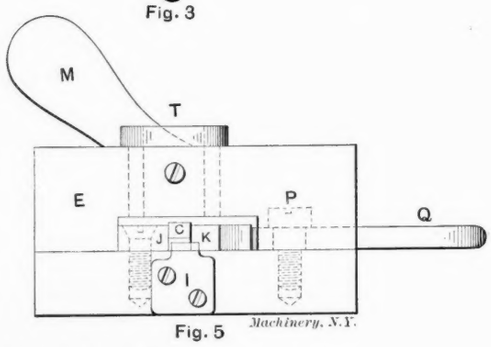


Fig. 5

Machinery, N.Y.

A Drill Press Jig for Milling the Semi-circular End on the Piece in Fig. 1.

The following explains the use of the jig, and the manner in which the work is machined to the shape and size shown at *C*. A cutting tool of the hollow mill type, the outside of which was left plain and the same diameter as the hole in the guide bushing *T* was made for the drill press spindle. The jig is placed on the drill-press table, the levers *M* and *Q* are released, the work is inserted and located against the stop as shown in Figs. 2 and 4, the lever *M* is pulled up and then lever *Q* pulled out, whereupon the work being securely located and fastened within the fixture and against the positive stops, the hollow mill is fed down into the bushing *T* until the part *C* of the work is machined to the shape and size required. In order to insure the production of clean, well-finished, and accurately surfaced work, the cutting tool had to be carefully and accurately made and its cutting edges well stoned at regular intervals.

JOSEPH V. WOODWORTH.

Brooklyn, N. Y.

LOOSE PULLEYS.

Editor MACHINERY:

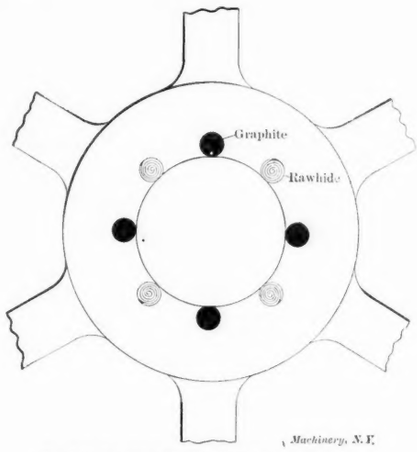
Of all known mechanical devices the loose pulley has probably caused more navy blue profanity first and last than all the others put together. There are very few of us in the mechanical line who have not at frequent intervals come into violent contact with the loose pulley of commerce. Now I ask you, my friends, why so crude a thing is put upon the market? You reply, because there is no substitute for it as yet. In other words, it is made cheap because it is sold cheap in order to compete. But the results of its use are far from cheap if we did but know it.

Now, during my twenty-eight years of mechanical experience I have never seen a loose pulley that proved to be a complete success. Far from it! All machinery requiring loose pulleys that I have so far designed, I am sorry to confess, follows, as far as the pulleys are concerned, the time-honored custom; that is, a simple hole drilled through the hub to the bearing and a wooden plug inserted to retain the oil and keep out the dust. It seems strange that a man of my experience should accept such a makeshift design as final and embody it in the construction of new machinery, which in my case is all special and therefore the fault is less excusable. My defense is that I am following an almost universal practice of the present time, which shows a lack of thought on this important subject.

Shall the loose pulley of the future be designed to run wet or dry, is the first question; but there is no question as to how most of them do run at the present time. It brings a well-known fact that they run dry mostly, hence the trouble. Therefore it would seem, not being able to keep oil in them for any length of time, that the only remedy would be to so design them as to run properly without oil. That is, perfectly

dry. It is obvious that this result can be accomplished by substituting rolling friction for sliding friction through the use of ball bearings. But this would be too expensive, says the manufacturer, holding up his hands in holy horror; it would ruin my business. I could not compete successfully with the time-honored device of my competitors. Therefore the application of ball bearings to loose pulleys must, to succeed, be universally adopted by makers of machinery.

Now the only other practical way that remains to be considered is to return to sliding friction. But instead of trying to use oil as a lubricant we will fill inner sections of the hub with dry lubricant such as graphite or a substance of like nature interposed with like sections of rawhide or asbestos fiber.



Design for Dry-lubricating a Loose Pulley.

The lubricating and antifriction material could be forced into these cored holes from the end of hub very nicely, as the holes run clear through from end to end of hub, or in other words, are open at both ends. After the rough casting has been filled with the antifriction material and allowed to dry hard the hub is bored out the right size and the pulley otherwise finished complete the same as usual. Now in boring out to size it will be noticed the main or shaft hole cuts into the series of small cored holes surrounding it, thus laying bare narrow sections of the lubricating material, the whole length of bearing, alternating with graphite, cast iron, rawhide, cast iron, graphite, cast iron, and so on around. Between the hubs of the tight and loose pulleys and also between the hub of the loose pulley and collar there should be interposed a thin rawhide washer, thus making a loose pulley of great durability and cheapness and requiring no attention whatever.

BRISTOL.

THREE-PIECE ELLISOGRAPH AGAIN.

Editor MACHINERY:

In the March issue Mr. Charles G. Taylor suggests two improvements in regard to the "Three-Piece Ellipograph" which I described in the November (1904) issue. The first improvement I need not mention as Mr. Taylor himself says that the second is the better, and consists of using "but the one screw, making some modifications in its shape and application." If Mr. Taylor had appreciated the fact that I was not describing some theoretical proposition, but telling of a model that we actually built and had in actual operation, he might have realized that the single wood screw which I had in the center of the apparatus was there for the identical selfsame purpose as the fancy fillister head screw which he suggests as being, "a still better plan." Mr. Taylor seems to have gotten the idea into his head I got hold of that screw and tightened it to such an extent that the apparatus could not work, for he states, "Now if this screw is screwed in tightly, Fig. 3 cannot move." Of course it couldn't; who would expect it to? It seems to me that at first Mr. Taylor failed to grasp the "*modus operandi*" of the apparatus and when the idea eventually "filtered" he mistook it for something new and accordingly sends it in as a "still better plan."

In regard to the minor improvements which Mr. Taylor suggests, they hardly warrant further discussion as no one would seriously consider an ellipograph made of wood for practical work. However, I might add a word in regard to Mr. Taylor's last suggestion, viz., "In using this device, the top circular plate should be lifted off and Fig. 2 moved the distance off center required for the radius of the longer diameter of the ellipse. The screw should then be tightened and the top plate put on." It seems to me that any adjusting device that requires the removal of the pencil or tracer, the removal of the top plate and replacing the same, and then re-adjusting the pencil, as Mr. Taylor's idea requires in order to change the ellipse, when the same end could be attained without disturbing anything, by merely drawing out Fig. 2 and clamping it in the required place, is about as undesirable a feature as one could conceive of. It would be about as ridiculous as an elliptical lathe chuck where we would have to remove the tool from the tool-post, remove the work and the faceplate, make the required adjustment and then replace everything.

Phœnix, Ariz. JOHN D. ADAMS.

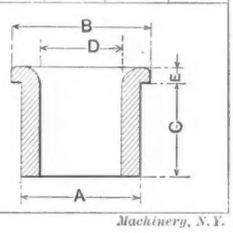
BUSHINGS FOR DRILLING AND REAMING JIGS.

Editor MACHINERY:

The accompanying table of drilling and reaming jigs gives the dimensions, as per diagram, that have been adopted as standard by a large manufacturing concern in Chicago. It will be noticed that the shoulders are much smaller than generally used, and in my estimation there is no need for the shoulder of a loose or removable bushing to be larger than is necessary for a good finger hold. By keeping the shoulder dimensions down to the figures given in the table, a considerable saving of steel is effected in the larger sizes, and when this amount is multiplied by the thousands of bushings necessary in the works referred to, it becomes a very important matter. Another feature of economy in making these bushings is the use of machine steel, casehardened, which gives as good results for this work as tool steel, and of course is far less costly both in price per pound and in time required for working.

BUSHINGS FOR DRILLING AND REAMING JIGS.

D	A	B	C	E	D	A	B	C	E
3/16	3/16	7/16	1/8	3/32	1 5/8	2 1/4	2 1/2	1 1/2	1/4
1/4	1/2	5/8	5/8	3/32	1 3/4	2	2 11/16	1 1/2	1/4
5/16	7/16	11/16	5/8	3/32	1 7/8	2 5/16	2 7/8	1 1/2	1/4
3/8	1/2	11/16	5/8	1/8	2	2 1/4	3	1 1/2	5/16
7/16	1/2	3/4	3/8	1/8	2 1/4	3 1/16	3 3/8	1 1/2	5/16
1/2	1/2	13/16	3/4	1/8	2 1/2	3 3/16	3 5/8	1 1/2	5/16
7/16	7/8	1 1/8	3/4	1/8	2 3/4	3 5/16	3 7/8	1 1/2	5/16
5/8	1	1 3/8	3/4	1/8	3	4	4 3/8	1 1/2	5/16
11/16	1 1/16	1 1/4	3/4	1/8					
3/4	1 1/8	1 3/8	1	3/16					
13/16	1 3/16	1 3/8	1	3/16					
7/8	1 5/16	1 7/16	1	3/16					
15/16	1 3/8	1 7/16	1	3/16					
1	1 7/16	1 11/16	1 1/8	3/16					
1 1/8	1 5/8	1 7/8	1 1/8	3/16					
1 1/4	1 3/4	2	1 1/4	3/16					
1 3/8	1 15/16	2 3/16	1 1/4	3/16					
1 1/2	2 1/8	2 5/16	1 1/2	1/4					

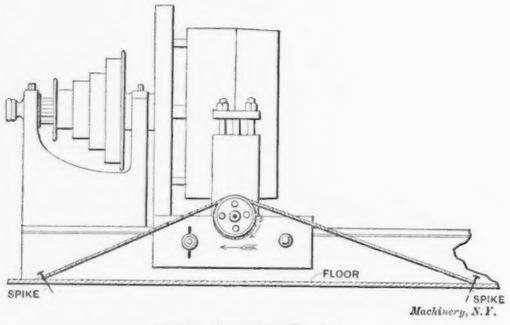


Machinery, N.Y.

PULLEY CROWNING DEVICE.

Editor MACHINERY:

A number of years ago when I was much younger than I am now, and machine shops did not have special tools for doing work as they have at present, I had a job of boring and turning a number of large pulleys, with only an ordinary 72-inch lathe, and very poor appliances for handling them. These pulleys would just swing over the carriage and were about 20 inches face, and had to be turned crowning. The only way to do them was to chuck them on the face plate, bore them, take a cut across the face, take them out of the lathe, drive a mandrel into them, and finish them on centers. That was a lot of work and took some time, moreover, as there was no reamer to size the pulleys and they had to be bored very close in order to be able to use one mandrel for all of them, I think about a dozen altogether. So while boring the first pulley I figured how I could save time and labor on the job, and I hit on the rig I have sketched.



Pulley Crowning Device.

First I found out what part of a turn the screw on the cross-feed had to make to get the desired crown while the tool traveled over half the face of the pulley, and I hunted in the scrap and stock pile for a pulley large enough to turn the screw sufficiently far to feed in the proper amount. I also hunted up a piece of rope that would not stretch much, taking finally a braided rope about 20 feet long, such as is used to drive portable drills, etc., and tied a loop in each end. I drove a spike in the floor in line with the pulley which had been fitted on the cross screw in place of the crank hands, took one turn around the pulley with the rope, and, after fastening a close coiled spring a foot long to one end of the rope, drove another spike in the floor on the other side of the carrriage the proper distance so that when the rope was connected to both spikes and turned once around the pulley, the spring put tension enough on the rope to keep the pulley from slipping while the carriage moved. I put the spring on the end toward which the carriage traveled so that there was no give to the rope, and when I wanted to run the tool the other way I just changed ends with the rope, which was very easy owing to the spring. I know that there are several ways of accomplishing the same object, but I think this way has several good points, one of which is that it may be used without much expense.

Milwaukee, Wis. THEODORE DISCH.

ANISOMETRIC PROJECTION.

Editor MACHINERY:

This is a variety of axonometric or triaxial projection, in which all lines that are parallel in the object represented are parallel in the drawing; also, the value of all lines in the direction of any one axis may be measured on one and the same scale, but for each axis a different scale is needed.

Proportions of the Axes.	Angles made by the Non-vertical Axes with the Projection Axis *A B*.	
1:0. 5:0.9	17° 49′	5° 11′
1:0. 5:0.75	8° 51′	2° 51′
1:0.75:0.875	24° 46′	16° 59½′
1:0. 4:0.95	24° 22′	3° 49½′
1:0.33:0.95	13° 32½′	1° 36½′

Foreshortening of the Axes.			Natural Sines of the Angles made by the Non vertical Axes *O Y*, *O Z*. with the projection Axis *A B*.	
O X	*O Y*	*O Z*		
0.9853	0.4927	0.8868	0.3060	0.0903
0.9961	0.4981	0.8716	0.1539	0.0497
0.9269	0.6951	0.8110	0.4189	0.2922
0.9847	0.3939	0.9335	0.4126	0.0666
0.9966	0.3322	0.9468	0.2313	0.0281

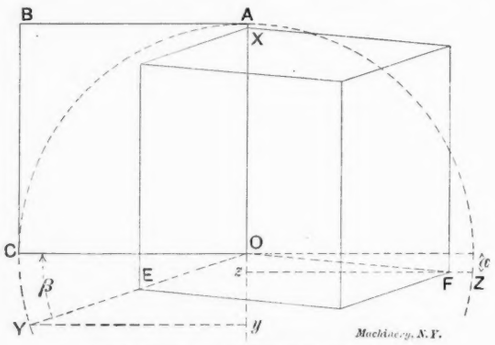
Tables for use in Anisometric Drawing.

In this it differs from the monodimetric, where dimensions in two axial directions are measured on one and the same scale, but those in the direction of the other axis on a different one; also from the isometric, in which all dimensions in any axial direction are measured on one and the same scale, and the three axes stand at equal angles with one another.

In this system one can choose any desired relation between the lengths of the lines representing equal lengths in the three axial directions; and for each set of lengths or of proportional foreshortenings, there is a set of angles at which the axes stand to one another and to the horizontal. One of these latter axial directions is usually chosen as 90 degrees or vertical; this may have the greatest or the least amount of foreshortening or may be between these two.

A table herewith shows for several relative axial proportions the angles at which the two non-vertical axes stand to the horizontal, the amount of foreshortening that takes place along either axis (as compared with the lengths on geometrical plan and elevations) and the sines of the afore-mentioned angles.

Referring to the sketch, we will draw *ABCO* to represent in elevation a cube, which it is proposed to draw in an anisometric projection where the relation of the axes is about 1:0.5:0.9. From the table we learn that the respective foreshortenings corresponding to the angles of this projection are for OX 0.9853, for *OY* 0.4927, and *OZ* 0.8868; and that the natural sines of the given angles $\beta = 17° 49'$ and $\alpha = 5° 11'$ are 0.3060 and 0.0903. If, then, *AB* is the edge of the cube which we wish to draw, and *ABCO* the face, we lay off $AX = 0.9853$ AO; and with radius, *OC*, strike the arcs, *CY* and *DZ*. On *AO* produced we measure $Oy = 0.3060$ and $Oz = 0.0903$, and draw *Yy* and *Zz* to cut *CY* and *DZ*. Then, on *OY* and *OZ*, which are the foreshortened axes, we lay off $OE = 0.4927$ *AO*, and $OF = 0.8868$ *AO;* we can then complete the cube.



Cube Drawn by Anisometric Projection.

Hanover, Germany. ROBERT GRIMSHAW.

PUNCH AND DIE FOR MAKING SQUARE NUTS.

Editor MACHINERY:

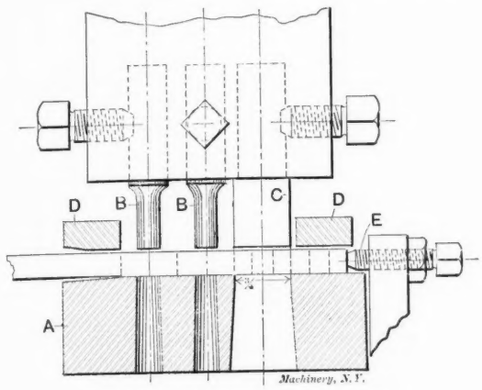
The following experiment with punch and die work may be of interest to some of your readers confronted with similar problems.

In an agricultural implement manufactory there was required about thirty tons of square nuts suitable for a ⅜-inch tap. It was thought that they could be much more economically made on the premises than they could be purchased. The iron was accordingly ordered in 16-foot bars, 5-16 x ¾ inch, and it was planned to punch the holes and cut off the pierced nut at one stroke of the press. A punching press was accordingly fitted up on this plan, but it was found to be not much of a success, for the reason that if the iron was fed in over the cutting-off die, the exact width of a nut, the latter would bend downward as the punch was forced down, and make a badly-shaped nut, or the cutting-off punch would be broken. Sometimes the piercing punches were also broken by the strain put upon them. Passing the iron in far enough to give the extreme end a bearing on the far side of the die, or making the cutting-off punch and die smaller and trimming the nut on all four sides did not seem to help matters much, and it produced considerable scrap.

After a couple of weeks experimenting with no improvement in the results, the plan was finally abandoned and some new device looked for that promised better success. The iron had been rolled with very flat edges and good corners, and as the nuts were all painted after being put in place, it was not necessary that they should be trimmed on all four sides. A new man took up the problem, and had the press fitted up with the punches and die as shown in the accompanying engraving. *A* is the die, pierced with two circular holes for the two piercing punches *B*, and a square hole ¾ x ⅞ inch for the cutting-off punch *C*, this hole being made wider so as not to trim the sides of the iron. Two strippers *D* are set very closely down

to the iron so as to confine it in place vertically, as closely as possible and still allow it to be freely pushed through by hand, while it was held laterally by pins fixed in the strippers.

In operation the bar of iron was fed in with its rough end against the stop-screw *E*, and at the first stroke of the press two nuts were pierced, one complete nut cut off, and the rough end left as waste. The first whole nut on each bar was therefore a blank and must be pierced in another press, but the balance of the bar was cut up into nuts with no waste but the piercings, and as the two nuts were cut off and pierced at each stroke of the press, the output of the machine was doubled. The nut forced against the stopscrew *E* was thrown out at one side by an ejecting lever (not shown) forced forward by a spring, and actuated by a ratchet wheel and pawl, whose carrying lever was operated by a connection with the press ram, by means of which, on its upward



Punch and Die for making Square Nuts.

movement, the lever was released, the nut ejected, and the lever set for the next stroke. A friction roll feed might probably have been added to advantage, but the operator seemed to have no need of it.

In the former plan it was found difficult to prevent scrap from collecting on the die, between the cutting-off punch and the stop-screw. By this plan no difficulty was experienced. The results of this arrangement were, that the output of the press was doubled, there was no difficulty with broken punches, and no scrap but the bits at each end of the sixteen-foot bars and the piercings. The press worked up considerably over thirty tons of stock, with no expense for repairs save grinding punches and replacing them when worn too short for further use.

OSCAR E. PERRIGO.

New Haven, Conn.

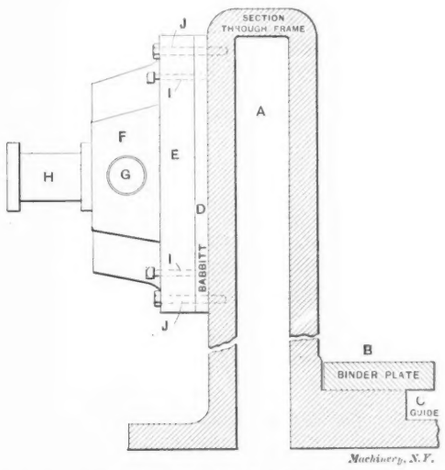
MAKING A JOINT ON ROUGH SURFACES BY THE AID OF SOFT METAL.

Editor MACHINERY:

Two rough surfaces sometimes come together in the construction of machinery because of a change in the design, hence, where no fitting pieces have been provided. Nevertheless such a joint must be strong and firmly made, and part of the attached piece must have a position in line with and parallel to some other part, say the center line of the cylinder of an engine, as once occurred with me in the erection of a number of compressor engines for compressing and pumping carbonic acid gas. Similar joints can be made to equal the best faced joints by the use of Babbitt metal or a metal composed of 8 parts of lead to 1 of antimony.

Before describing the job I may mention that the steam engines of the carbonic acid gas compressors I erected were of the double-disk crank type, with overhanging fly-wheels. The steam cylinders were attached to one side of the bed and overhanging, and measured about 16x18 inches, while the compressor cylinders were 22 inches in diameter. The pump cylinder stood on a plate bolted to a foundation distant from that of the steam engine, but connected with the steam cylinder by two bolts or rods 2½ to 3 inches in diameter. The stuffing-boxes at either end of both cylinders were packed with metallic packing, alternate rings of gun metal and babbitt metal being fitted together with bevel joints, thus insuring the central location of the pistons, which both extended through the stuffing-boxes in the heads of the respective cylinders, and preventing their dragging on the bottoms of the cylinders. For connecting the piston rods of the steam engine and the compressor, the best device was used that I ever saw, since it permitted a fine adjustment in the location of the pistons, was easily detachable for repairs and easily assembled again, and was firm and tight when put together. A V-thread was cut on the end of both piston rods, 8 threads to an inch and 5 inches long. A connecting nut 8 inches long was used, parted horizontally through the center, the joints being planed open about 3/16 inch, and assembled by four bolts provided with jam-nuts. The steam piston rod was secured to the crosshead in the same manner, a cap being parted horizontally from the shoe or bottom part which slid in the guide.

The valves of the pump or compressor were originally of the poppet type, set horizontally in the cylinder heads of the pump and worked by the gas like the valves of a pump. By their frequent breaking, however, these gave so much trouble that a slide valve was adopted, worked like the slide valve of an engine by an eccentric on the crank shaft, the eccentric-rod taking hold of a pin, *H*, in the sliding head *F* attached to the valve stem, *G*. The sliding head, of course, must move true and parallel with the center line of the valve. Since no fitting pieces had been cast on the engine bed, the slide valve being an improvement due to an afterthought, it was necessary, in order to make the guide true with the face of the valve and parallel with the center line of the valve seat, to make the joint by running soft metal under the guide, that is, between the guide *E* and the engine bed *A* after the guide was located in position. The guide *E* was a flat plate 1¼ inches thick, and about 10 inches wide by 12 inches long, with projections planed to receive the sliding head and its gibs. It was drilled for seven or eight stud bolts, *J*, and six ⅝ tap holes were drilled for adjusting setscrews. These six setscrews, *I*, were to adjust the guide plate with its planed surface parallel with the center line of the valve stem, the vertical adjustment being made by a spirit level since the center line of the engine or axis of the cylinders was level. To locate the guide I first chalked the engine bed and held the guide in place by a light jack screw resting on a heavy saw-horse weighted down by pig iron. I then placed a piece of plank, planed true, against



Joint between a Guide and an Engine Bed made of Soft Metal.

the edge of the guide *C* for the crosshead, and set the guide plate true by measuring from the plank to the planed edge of the guide plate with a pair of large outside calipers. After the plate was true and level, I scribed the bolt heads, removed the plate, drilled and tapped the stud bolt holes, readjusted the guide plate, stopped the opening around the edges with strips of dry pine planed true, covered the cracks by well worked clay and poured in the metal, using a pretty good riser to insure its filling the space perfectly. When the soft metal, *D*, had cooled, I took out the setscrews and screwed up the nuts as much as I could, and the guide was as firmly located as though against a planed joint.

C. E. MINK.

Syracuse, N. Y.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

TO PREPARE EMERY FOR FINE LAPPING.

Emery for very fine lapping work must be sifted and resifted, and I have used the alternative process here described with very good results. Place 2 pounds of flour emery in a linen cloth a foot square, tying the edges together so that no emery can escape. Sift the emery on a clean sheet of paper by easily rapping the bag on the paper so that only the finest grains will work through. Put the sifted emery into a glass with about 4 times as much good lard oil, mix well, and let stand for 10 hours. After this settling, run the fluid carefully into another glass, leaving the deposit of the heavier grains of emery behind. Repeat this two or three times, and the result will be an extra fine preparation for lapping the finest plugs, rings, etc.

Jos. M. Stabel.

Rochester, N. Y.

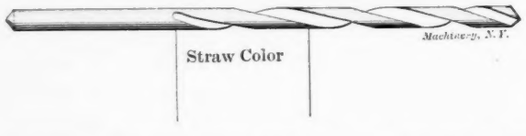
TO HARDEN THIN SAWS WITHOUT WARPING.

I have hit on a way of hardening thin saws and disks without warping, which is quite satisfactory. I use two iron blocks, dropping the hot saw upon one block and clapping the other block on top of it. I use these blocks dry and get better results than by the usual method of flooding with oil. The reason I believe to be this: When the hot saw is dropped onto the dry block or plate it cools from the outside, but the top plate being immediately dropped upon it straightens it out and chills it into a perfectly flat shape. If the lower plate is flooded with oil, however, the saw cools and sets before the upper plate can be clapped upon it, hence it comes out warped. I have hardened slitting saws up to 0.022 and 0.034 inch thick by this method and have found them tough and capable of standing rather rough treatment.

Belvidere, Ill. V. H. Marcellus.

TO REDUCE SMALL DRILL BREAKAGE.

Foremen having men or boys who break an excessive number of small drills, may reduce the number somewhat, if they take the advice given to me by an old English machinist. If the drill is drawn to a straw color at the section shown in the



cut, it reduces the brittleness and consequently the liability to snap off so easily. This little wrinkle may not be new to some, but it was to me, and as it has effected quite a saving in our expense for small drills, we naturally feel that others will appreciate it.

Lancaster, Pa. Park B. Shee.

SOLDERING ALUMINUM.

Several years ago I made some experiments on soldering aluminum, and found that aluminum could be soldered with ordinary solder (equal parts of lead and tin) and no flux at all. My successful experiments were as follows:

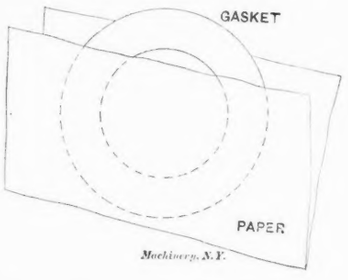
Taking a piece of sheet aluminum I would gradually heat it, at the same time rub it vigorously with a very hot soldering iron; in a short time a dirty substance would apparently work out of the metal that looked very much like the scum that comes on the surface of melted Babbitt metal. Directly after this the solder would begin to adhere to the aluminum, and it could be tinned quite nicely; after being tinned it was an easy matter to sweat or solder the pieces together.

I had heard that solder would come loose from the aluminum after a while, when soldered by the methods then in use, so I put away some of the pieces I had soldered in this manner, to observe the action of time on them, and they remained in good shape as long as I had them. I finally lost them and have never since repeated the experiment. I have since read that aluminum could be welded by careful manipulation at a temperature slightly below the melting point; if this is true it seems very reasonable that soldering by this method will be permanent. It is possible that I brought the pieces to the welding heat in tinning but this seems improbable.

Indianapolis, Ind. R. Earl Weinland.

CUTTING AND APPLYING GASKETS.

In cutting rubber for gaskets, etc., have a dish of water at hand and keep wetting the cutter. This method has been used on rubber packing washers 1 inch thick with excellent results. When putting a gasket in place chalk the flanges, and you will not have so much trouble in removing the gasket when the



joint is broken. Often two flanges cannot be separated any great distance and one has trouble in inserting the gasket; put it between a folded sheet of paper as indicated in the sketch and it can be placed quite easily. The paper can be torn out after some of the bolts are entered.

James A. Pratt.

Howard, R. I.

RIG FOR MILLING THE UNDER SIDE OF BOLT HEADS.

Having a number of screws of the type shown in Fig. 1 to mill under the heads, as indicated in Fig. 2, I devised the fixture illustrated in Figs. 3 and 4. It consists of the body *A* made of mild steel. It was planed all over, and a groove was cut through the body lengthways which was made of the same width as the diameter of the body of the screw. A hole was counterbored in the center to a depth equal to the thickness of the head after being milled. Two clamps *B* were made of steel, which were hardened to prevent bending. These were machined to fit the groove, thus keeping them from shifting sideways and always in line with the body of the screw to be milled. The two binding screws *C* were also made of steel hardened.

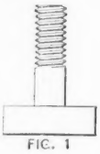


FIG. 1

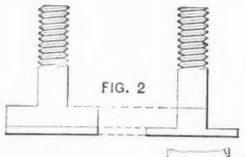


FIG. 2

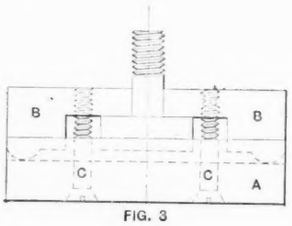


FIG. 3

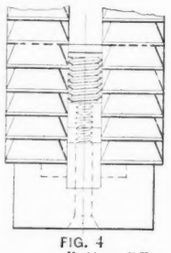


FIG. 4

Machinery, N.Y.

A pair of 4-inch straddle mills held apart by a collar of a width equal to the diameter of the screw was used to mill the heads. After placing a screw in the fixture as shown in the cuts, Figs. 3 and 4, the fixture was placed in the vise on the milling machine, the straddle mills being set to the clamps for position sidewise, and just touching the body of the fixture for the vertical position. With the rig it was possible to mill the heads with only one cut and it was found quite satisfactory, especially as the screws had no centers and it would have been a difficult job to mill them otherwise without some special fixture.

W. C. F.

SHOP RECEIPTS AND FORMULAS.

Practical Tried Receipts—those known to be Good—are Solicited.

FROSTING BRASS-WORK.

Boil the brass in caustic potash, rinse in clean water, and dip in nitric acid till all oxide is removed; then wash quickly, dry in warm boxwood sawdust, and lacquer while warm. This will give brass an ornamental finish.

Angelica, N. Y. F. H. JACKSON.

GLUE FOR LEATHER BELTS.

Take common glue and isinglass, equal parts; place them in a glue pot, cover with water, let soak 10 hours, bring to a boiling heat, add pure tannin to make to consistency of the white of an egg. Apply warm, have surfaces clean and dry; clamp joint firmly and let dry. L. E. MUNCY.

Syracuse, N. Y.

SOLUTION FOR DRILLING HARD STEEL.

A mixture which will permit hard steel or iron to be drilled with ordinary drills is made by using 1 part spirits of camphor and 4 parts turpentine. Mix well and apply cold, letting it remain a few minutes before applying the drill. Run the drill slowly with fine feed. C. E. MINK.

Syracuse, N. Y.

TO WATERPROOF GLUED JOINTS.

To render glued joints waterproof, rub common chalk on the surface of the wood where the glue is to be applied, and then coat with ordinary glue in the usual manner. The chalk will protect the glue from moisture so that the joint will hold as well after being soaked in water as before. I tested this method some time ago and found that it works very well.

Lansing, Mich. W. S. LEONARD.

PERMANENT IRON CEMENT FOR STEAM PIPES.

To make a permanent cement used for stopping leaks in steam pipes where calking or plugging is impossible, mix black oxide of manganese and raw linseed oil, using enough oil with the manganese to bring it to a thick paste; apply to the pipe or joint at leak. It is best to remove pressure from the pipe and keep it sufficiently warm to absorb the oil from the manganese. In twenty-four hours the cement will be as hard as the iron pipe. JAMES H. TAYLOR.

Oswego, N. Y.

TO BLACKEN BRASS FOR TEMPLET WORK AND OTHER PURPOSES.

The brass must be thoroughly cleaned, and then is heated slowly over a charcoal fire, care being taken not to allow the brass to touch the charcoal, or indeed not to allow any sparks from the charcoal to come in contact with the brass or it will cause red spots. As soon as the brass is slightly red, dip it into nitric acid and reheat, just short of red. Rub strongly with a stiff bristle brush and clean with a greasy cloth. This gives a fairly permanent dead black finish.

P. H. OTO.

MIXTURE FOR PLUGGING HOLES IN CAST IRON.

A good mixture for plugging blowholes in cast iron is made of sulphur, cast-iron borings sifted very fine, and graphite. Melt the sulphur in an iron ladle and stir in as much of the sifted borings as the sulphur will allow, not making it too thick to pour readily. Add a small quantity of the graphite, say a tablespoonful to a quart of the mixture. Pour into the holes while hot, and after it is cool smooth off with a file. When holes are filled with this mixture on surfaces to be machined, a finishing cut can be taken over it which will obliterate the holes. R. B. CASEY.

Schenectady, N. Y.

TO KEEP MACHINERY FROM RUSTING.

A formula for an anti-rust compound is made as follows: Dissolve 1 ounce of camphor in 1 pound of melted lard; take off the scum, and mix in as much fine black lead as will give it color. Clean the machinery, and smear it with the mixture; and after 24 hours rub clean with a soft linen cloth. The machinery will keep clean, under ordinary circumstances, for a long time. JAMES A. PRATT.

Howard, R. I.

NON-CORROSIVE SOLDERING FLUID.

In "How and Why" of the September, 1904, issue of MACHINERY, I notice a formula for a non-corrosive soldering fluid which is not given in what I consider the most economical form. I put any quantity of chloride of zinc in a bottle, fill it up with alcohol, and allow it to stand at least 48 hours, then carefully pour off the alcohol, mix with an equal quantity of glycerine and shake. The zinc remaining in the bottle can be used until there is nothing left of it, since the alcohol which is poured off after 48 hours contains all the chloride of zinc which is necessary for good soldering. It is not necesssary to use glycerine, the office of the glycerine being merely to keep the alcohol from spreading. HERMAN JONSON.

New York.

PASTE FOR HARDENING HIGH-SPEED STEEL.

The hardening paste made according to the following receipt has been used on high-speed steel with success, enabling it to be hardened by heating in an ordinary gas oven, and thus making unnecessary the very high heat usually called for in hardening such steels. Mix 2 pounds rye meal; 1 pound common salt; ¼ pound pulverized borax; ¼ pound pulverized charcoal; 1-3 pint (or ½ pound) liquid cyanide of potassium; ½ gill or 2 ounces of water glass (silicate of soda); and 3 pints of water. The liquid cyanide is made by dissolving 3 ounces of pulverized potassium cyanide in one pint of boiling water. Mix thoroughly to form a paste.

When using this paste I have found it best to apply it in the following manner: Provide a small cast-iron vessel or a crucible of the shape of a drip-pan, and spread a thin layer of the paste on the bottom; put the work in the pan and cover that with paste also. Place work and pan in the gas oven and heat until it reaches a nice full red. Dip in sperm, fish or kerosene oil. JOS. M. STABEL.

Rochester, N. Y.

SOLDERING ACID AND SOLDERS.

I have seen a number of different formulas for soldering acids and have had occasion to try several of them with more or less satisfaction. Among all the different ones which I have tried, I know of but one, however, that actually can be said to fill all requirements. As the formula for this acid is not generally known it may be valuable to the readers of MACHINERY to add same to their collection. The acid is composed of: Solution chloride zinc, 1 ounce; glycerine, 1 ounce; alcohol, 7 ounces.

As far as the solder itself is concerned, one can, of course, make compositions of tin and lead in almost any proportions to fill the requirements in general. The melting point of these different compositions will vary greatly, however, according to the proportions of above metals in same, and, of course, this is an important factor in many instances, especially when wanting to solder metals which have a low melting temperature, in which case the solder ought to be a composition which itself will melt at a very low temperature. If bismuth is added to the composition the melting temperature will almost invariably be lowered. I have on hand a fairly complete table of compositions for solder giving their respective melting temperatures and the metals for which they are best adapted.

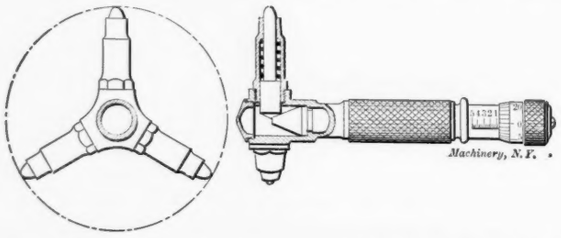
Tin.	Lead.	Bismuth.	Melting Temperature. Degrees Fahr.
15.5	32.0	52.5	205
20.0	26.0	54.0	214
20.6	26.8	52.6	217
21.4	27.8	50.8	225
24.8	22.1	53.1	237
20.0	20.0	60.0	250
15.0	25.0	60.0	257
63.2	36.8		361
60.0	40.0		372
70.0	30.0		381
50.0	50.0		415
34.0	66.0		446
30.0	70.0		495

A.

ITEMS OF MECHANICAL INTEREST.

NOTES OF A VARIED CHARACTER GATHERED FROM DIFFERENT SOURCES.

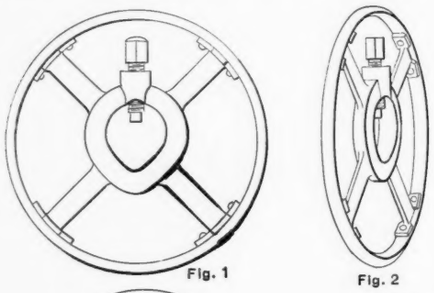
We illustrate herewith a precision gage taken from the *Portefeuille Economique des Machines* for February, for measuring exactly the diameter of a drilled hole. This, as may be seen, is a modification of the well-known star gage, used for getting the inside diameter of rings, etc., in gun work. It is composed of three radially-disposed stems, which are moved outward together by a cone, placed on the end of a micrometer screw carrying a vernier, by which readings to hundredths of a millimeter may be obtained. These stems are kept in engage-

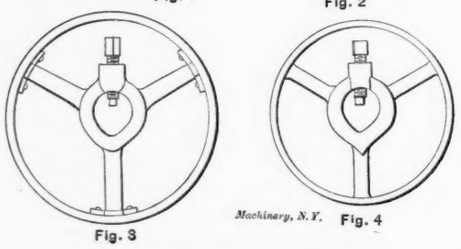


ment with the cone by spiral springs. The three points can be replaced by sets of longer points for measuring the diameters of larger holes. With these sets of points and two instruments, one of 12 millimeters and the other of 27 millimeters movement, it is stated that the greater number of drilled holes met with in practice can be measured. This gage has the advantage as compared with the ordinary inside micrometer gage, that the roundness of the hole as well as its diameter can be accurately determined.

SAFETY LATHE DOG.

A safety lathe dog intended to prevent machinists' clothes catching therein is illustrated in the accompanying cuts. Mr. Robert Grimshaw, Hanover, Germany, says, although the idea is covered in Germany by a design patent, it is not patentable in any country. It is made in Germany by Albert Koch & Co., Neuss a. Rh. As will be seen from the illustrations, the idea



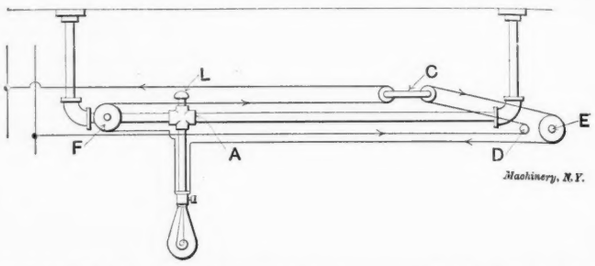


is simply surrounding the ordinary lathe dog by a rim attached to same by arms, making the contour of the dog that of a pulley or wheel. A possible advantage of this design, aside from the safety feature, is that it is more nearly balanced than the ordinary type, hence would not have as great a disturbing effect due to want of balance when running at high speed.

PORTABLE LAMP SUSPENSION WITHOUT LOOSE WIRES.

A correspondent of the *Western Electrician* describes a method of suspending an electric lamp over a work bench or lathe by which it may be shifted from one end to the other without having loose wires as is necessary with the ordinary flexible connections. These are always a source of annoyance and are sometimes dangerous for one never knows when such connections may become abraded or cut so as to cause a short circuit.

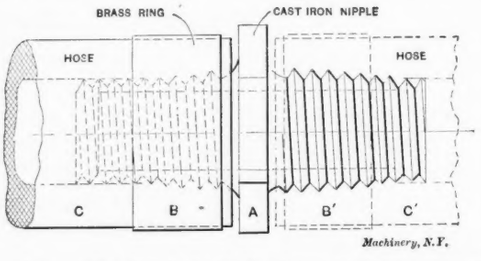
The frame is made of ¼ or ⅜-inch pipe attached to the ceiling by floor plates. *A* is a pipe-cross drilled out so it will slide upon the pipe, with a thumb screw *L* threaded through a pipe plug and used to fasten the lamp up out of the way when not in use and also to fasten it at any angle when in use. The



arrows indicate the direction of the current in the lamp cord. Two movable pulleys linked together are shown at *C*. *D* is a porcelain knob to which the lamp cord is tied and *E* and *F* are fixed pulleys. The lamp and movable pulleys *C* move in opposite directions. As one cord lengthens the other shortens, and vice versa. The illustration is obviously diagrammatic and lacking in details, but the principle involved is clear. The supports for *D* and *E* should be upon the pipe frame itself and their connections to *C* should be in a horizontal line ininstead of being inclined as shown in the cut.

HOSE COUPLING.

The simple hose coupling shown in the cut is the design of Mr. W. B. Ward, of Richmond, Ind. It consists of a cast-iron nipple, *A*, having a narrow hexagon nut in the center, and two brass rings, *B*. The threads of the nipple are tapered and are cast in sharp V-form which cut their own thread in the interior of the hose as the nipple is screwed in. The feature of novelty, however, is in the application of the brass rings or bands, *B*, which are slipped upon the ends of the hose before the nipple

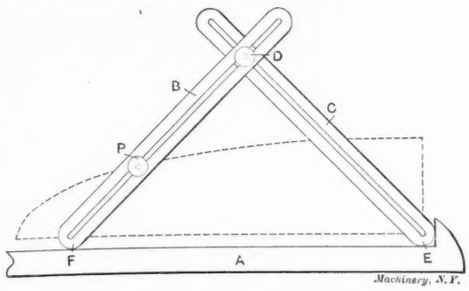


is screwed in. The bands hold the hose firmly so that it cannot expand over the threads and leak or slip off. While the invention was designed for connecting garden hose and has been used for that purpose only, we believe, this use does not seem to us to be its limitation, for the idea could doubtless be profitably used for securing hose fittings generally, especially air-brake hose, which as every one knows who is familiar with the subject, are rather awkwardly connected now,

SIMPLE DEVICE FOR DRAWING ELLIPTIC CURVES.

A correspondent of the *English Mechanic* describes a simple device for drawing elliptic curves which is not without interest and value. It has the merit of being quickly adjusted for any required major or minor axes within the limits of the instrument, but has the defect that only one-quarter of the ellipse can be drawn at one setting. *A* is a straightedge with a stop or projection at *E*. *B* and *C* are slotted rods, each having the lower ends truly rounded to perfect semi-circles for the obvious reason that any other shape would distort the shape of the curve. The rods are held together by a joint similar to that used in proportional compasses, that is, the joint may be fixed on the bars in any required proportion, and still allow them to swing on the joint as a pivot. At *P* is the holder for the pencil or scriber, and this also is adjustable in the slot. When

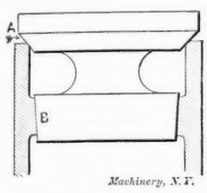
drawing an ellipse, the distance $F P$ is made equal to one-half the desired minor axis, and $P D$ must be made one-half the distance between the major and minor axes. The diagram shows clearly how the curve is drawn, and it will be noted that



a short section of the quarter ellipse must be drawn in free-hand, since the pencil at P will interfere with the bar C when nearing the vertical position.

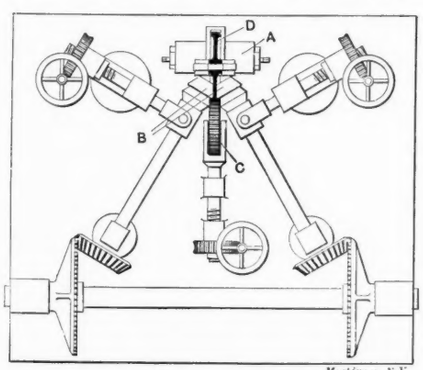
VALVE DISK DESIGN TO PREVENT CUTTING.

The greatest deteriorating influence to which the disk of stop valves is subjected, is the cutting action of the steam when the valve is being opened and closed. The high velocity of the steam passing through the constricted opening causes it to act very much like a sand blast, with the result that the seating surfaces are quickly scored and grooved, especially with high-pressure steam, making them leaky. A variety of schemes has been proposed for correcting this evil, and the one shown in the accompanying cut has been used in several shapes with more or less success. This particular device is used by Holden & Brooke, West Gorton, Manchester, England. The valve disk is extended downward so as to form a conical point B having a slight taper. When the disk is closed the piston B shuts off the flow of steam almost entirely before the disk seats at A. Hence the cutting or scoring effect is greatly reduced. It is claimed that valves with this design open and shut more easily than those of the ordinary plain disk type, and that they work very successfully under severe conditions.



TO MAKE GEAR WHEELS BY A ROLLING PROCESS.

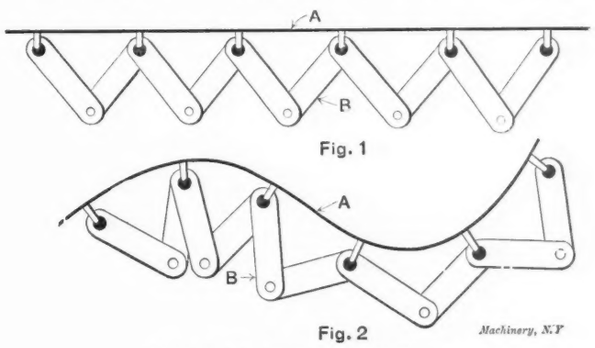
A British patent has been granted for a process of manufacturing gear wheels by rolling. The machine for doing the work is shown diagrammatically in plan view in the accompanying sketch. The block from which the gear wheel is to be made is first heated to forging temperature and shaped to a rough blank in a drop press. It is then mounted as shown at D and pressed into shape by the rollers B, while the hardened gear wheel C imprints the teeth upon its periphery. The



rollers and gear wheel are fed to their work by the hand wheels shown. The rolling process is very similar to that employed in the making of rolled steel car wheels, the face roller in this case being replaced by the toothed wheel C. While such a process may be possible and yield good results, it seems scarcely practicable save for some certain types of gears which are made in large quantities to standard dimensions, as, for instance, spur gears for street railway motors, etc.

FLEXIBLE CURVES FOR DRAFTSMEN.

We have received from W. J. Brooks, 33 Fitzroy Street, W., London, samples of the Brooks' flexible curves for draftsmen, two of which are illustrated herewith, Figs. 1, 2 and 3. Both of these styles are self-clamping, that is, when the curve has been adjusted it holds its shape. In Fig. 1 the construction is a flexible steel strip A to which are attached at intervals of about 1½ inches, the jointed pieces B. When the steel strip A is bent to a curve, the angular positions of the jointed bars are changed, and the friction of their joints holds the curve, as illustrated in Fig. 2. The construction of Fig. 3 is better adapted to long curves. The steel strip A is con-



Figs. 1 and 2. Brooks' Flexible Curve.

nected to light wooden strips B about 6 inches long which slide through clips D on the traverse wooden bar, C. The friction of these clips is sufficient to hold the strips in whatever position they may be set, and thus the shape of the curve is maintained. Both styles of curves can be reversed, that is, used either side up, which makes them convenient for symmetrical drawings. The third sample curve sent is made of transparent celluloid to which are attached celluloid finger-pads with which the shape of the curve is held with one hand while it is traced with the other. The fourth curve is made of steel on the same principle, hence, weights are depended upon to hold it in position while tracing a curve.

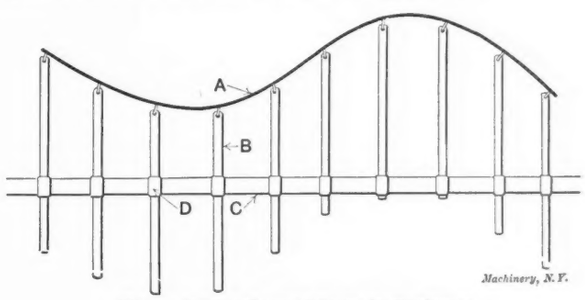


Fig. 3. Another Form of Curve for Draftsmen.

Accompanying the curves was a sample of the Brooks' parabola curve which is made very accurately from transparent celluloid by specially designed apparatus, and has its axis, focus, and latus rectum engraved upon it. While designed for the study of the parabola and to assist teachers of mathematics in the solving and demonstration of certain problems by the use of squared paper, it is quite useful as a set curve for draftsmen, and will be found a convenient addition to the drawing board. The axis line being drawn very accurately at right angles to the latus rectum, makes it a convenient means of drawing lines at right angles.

* * *

A fan capable of handling 3,000 cubic feet of air per minute, and a special form of heater designed to heat as a minimum 2,000 cubic feet of air per minute from 32 degrees to 200 degrees F., or a proportionately larger amount from a higher natural temperature, were recently furnished the Bureau of Engraving and Printing at Washington by the B. F. Sturtevant Co. It was stipulated that the coils should be so completely enclosed with thicknesses of asbestos, and so thoroughly insulated, as not to transmit heat to the room in which they were placed, which difficult conditions appear to have been met with success.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

40. P. M.—Can any of the readers of MACHINERY give me a formula for figuring the square inches of surface required on expansion ring frictions per horse-power, per each 100 revolutions?

41. J. S. W.—I need a grease or oil that will not freeze at, say, 40 degrees below zero, to use in a ball bearing. It need not be a good lubricant, as its principal purpose is merely to keep the balls from rusting. I think vaseline would probably do but cannot find out what its freezing point is. Can you tell me the most suitable grease for this purpose?

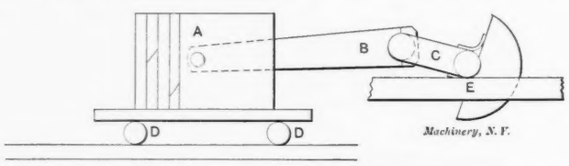
42. H. F. S.—Please state in "How and Why" how leather can be crimped like the enclosed cup leather, without spoiling its appearance. We have the dies and by wetting the leather are able to form it perfectly, but this blackens and roughens the surface of the leather. Dry, it will not crimp at all. What material can I use to coat the inner surface of the die to prevent rusting while in use—one that will not rust the leather? We submit this to our readers.

43. C. H. R.—What shrinkage allowance is generally made in drop-forging dies for copper?

A. We are informed that the practice of J. H. Williams & Co. is to make a general shrinkage allowance of 3-16 inch to the foot in drop-forging dies for copper.

44. J. V.—In balancing a high-speed gasoline engine, is it correct to balance one-half the weight of the connecting rod only; if so would it be right to balance the parts as illustrated in the cut, adding counterweight until the part of the connecting-rod supported by the crank-pin is balanced? The crank-shaft is supported on level ways and the piston rests on rollers also supported on level ways.

A. Practice differs. Some builders of gasoline engines balance the rotating parts only, which, of course, includes the crank and that part of the connecting rod which is regarded as rotating weight, only; and some balance one-half the reciprocating weight additional, that is, one-half the piston weight + remainder of connecting-rod weight. The method you illustrate should work all right to secure rotative balance effect only, if due care is taken to secure the greatest possible flexibility of

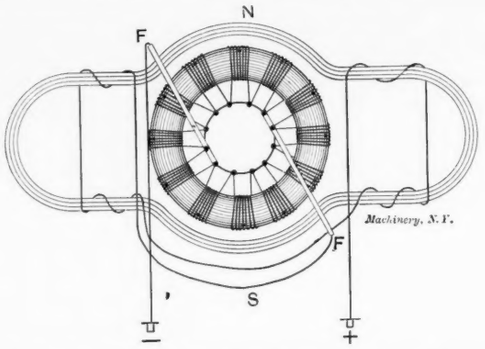


movement and to have the supporting surfaces level. A further refinement, which might be advisable with small engines, would be to test the condition of balance with a delicate spring scale. Thus, when you have added counterbalance so that crank *C* and connecting-rod *B* remain at rest when connected in a straight line, attach the spring scale to the crank-pin and note the upward pull that is required to start the linkage from a condition of rest; replace crank and connecting-rod in a straight line and then test the downward pull. When the pulls in both directions are the same you have taken into account the friction of rollers *D*, that of the connecting-rod bearings, and the negative effect of the rolling resistance of the crankshaft on *E*, hence the rotating effect should be balanced. But, whichever method is adopted, there will always be a want of balance in some direction since both the vertical and horizontal forces cannot be balanced at once in a simple engine. Moreover it is of importance, in a variable-speed engine, to make the center of gravity of the counterweight the same radial distance from the crank-shaft as the crank-pin; otherwise its effect with changes of speed does not increase or decrease proportionately with that of the crank-pin and parts connected thereto. The best way is to avoid the use of counterweights entirely and to have duplicate parts moving in opposite direction, hence the double and quadruple cylinder engines as used on automobiles, launches, etc. But even with this construction short connecting-rods have a serious disturbing influence at high speeds, and it is important that they be made as long as possible.

45. G. J. S.—In drilling holes, say 1¼ to 3 inches diameter, which is considered the best practice: to drill a small hole first in order to reduce the pressure on the point of the large drill, or to drill from the solid with the large drill alone?

A.—It is largely a matter of machine tool equipment; with the usual tool equipment found in machine shops it is unquestionably the best practice when drilling holes as large as three inches diameter, to drill a small hole first, especially in steel. The removal of the metal represented by the small hole (which is quickly made) greatly reduces the pressure on the drill-arm when using the large drill, and thus makes it feasible to use a much heavier feed than would otherwise be possible. In fact it probably would be impracticable with the great majority of drilling machines to drill a 3-inch hole from the solid as the necessary pressure would be disastrous. But if a drilling machine has been designed to stand the pressure of a 3-inch drill with heavy feed there should be little gain in drilling a small hole first. For the larger sizes of holes it is, of course, the general practice to drill, say a 2-inch hole first, and then enlarge with counterbores, but just where one practice supersedes the other is largely determined by the power and rigidity of the machine.

46. Novice.—I send sketch of a small motor I made—length of field magnet inside, 10½ inches; internal diameter of polar section 3⅝ inches; number of layers of wire to each coil, 5; number of convolutions in each layer, 34; size of wire



A. M. W. G. No. 16; number of coils on armature, 12; number of layers on each coil, 4; number of convolutions in each layer, 8; size of wire on armature A. M. W. G., No, 18. The machine runs all right as a motor but will not generate any current as a dynamo. I have run it at as high a speed as 2,500 revolutions per minute. Have changed the brushes, in fact, have done all that I can think of, but to no purpose. Can you enlighten me?

Answered by Wm. Baxter, Jr.

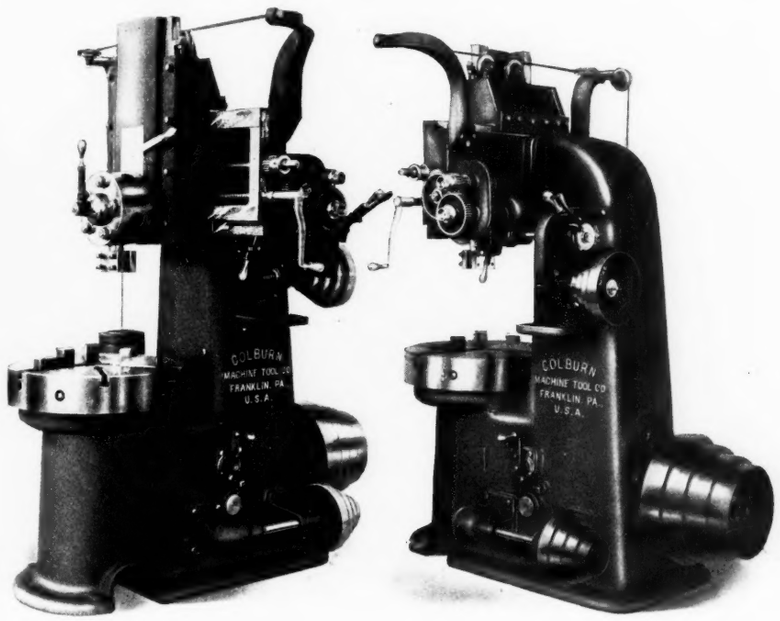
A.—Small motors will not run as generators as a rule. The reason why they will not run is, that the distance between the iron of the armature core and the faces of the poles *N S* is too great to permit the machine to build up the field magnetism. When a generator starts, the residual magnetism left in the field cores is sufficient to develop an electro-motive force in the armature great enough to start a current that is strong enough to increase the magnetism of the field. In this way the action gets a start, the small current generated in the armature increases the strength of the field magnetism, and this in turn increases the current generated by the armature. Thus the armature helps the field, and the field helps the armature. When a machine is very small, however, the distance between the iron of the armature and the pole faces is much greater in proportion than in a large field, the number of turns of wire on the field and armature is smaller in proportion, the resistance of the wire is greater in proportion and the residual magnetism is not so strong. All these differences put together prevent the small machine from generating. If the armature of the small machine is rotated at a high enough velocity it will generate, but this velocity might be greater than it would stand. If the poles are bored out true, and an armature is used with grooves to wind the coils in, so that the tops of the teeth will not be more than two hundredths of an inch from the pole faces, the machine will generate.

MACHINERY AND TOOLS.

A MONTHLY RECORD OF NEW APPLIANCES FOR THE SHOP.

THIRTY-INCH VERTICAL BORING MILL.

A vertical boring and turning mill recently brought out by the Colburn Machine Tool Co., Franklin, Pa., is illustrated in front and back views in the accompanying figures. The mill will take in work 18 inches high, and has a swing of 30 inches. It has 16 changes of speed in geometrical progression varying from 3.2 to 106.2 revolutions per minute.



Colburn Thirty-inch Vertical Mill.

The drive is from a spur pinion to the main driving gear bolted to the lower part of the table. The table spindle extends downward nearly to the floor, and has two large vertical bearings to resist side strains, as well as a large phosphor bronze conical bearing at the top, all these bearings being well lubricated. The back gears may be thrown in and out without stopping the machine by means of the handle shown at the side of the base. There are eight feeds driven by a wide belt running on feed cone pulleys of large diameter. The feeds are reversed by means of the hand lever shown directly above the upper feed cone pulley.

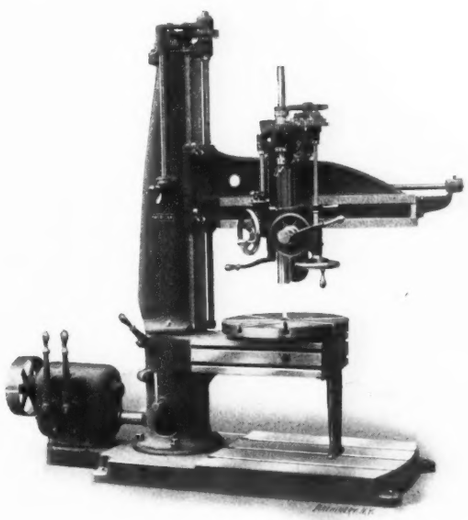
The vertical slide has a travel of 23 inches either by hand or power. Attached to the turret slide is a graduated scale 24 inches long, over which an adjustable pointer moves, indicating the travel of the turret slide. The cross slide has a travel of 17½ inches by hand or power, and is equipped with an automatic stop for tripping the feed before the head comes to the center stop. The turret is 10¼ inches in diameter, and has five holes bored to fit tool shanks 2¼ inches in diameter. The turret has a clamp lever which remains in a vertical position when relieved, as shown in Fig. 1. The lock bolt is of hardened tool steel, and works in a hardened tool steel index ring, bolt and ring both being accurately ground.

The mill can be furnished with a plain table, with or without chuck jaws, or with a 3- or 4-jaw combination, independent and universal chuck. A double friction countershaft is furnished, having two pulleys 14 and 20 inches in diameter for a 4-inch belt. Both pulleys run in the same direction, one at 150 and the other at 375 revolutions per minute. The weight of the mill is 4,500 pounds.

THREE-FOOT COMBINATION RADIAL DRILL.

The illustration shows a radial drill with 3-foot arm built by the American Tool Works Co., Cincinnati, O., which is preferably driven through a speed box, although a cone pulley drive may be used. The drill is built for the use of high speed steels; the column is of box girder type, revolves in a stationary stump carrying conical rollers, and is clamped securely in any position by means of the lever near the foot. It is capable of being swung in a complete circle unless arrested by the belt, if driven from overhead. The arm is of parabolic beam section, and its lower line is parallel with the base, thus permitting work to be operated upon close to the column. The arm is clamped to the column by binder levers, and is raised and lowered by the double-thread coarse-pitch screw hung on ball bearings and controlled by a convenient lever.

The speed box is of the geared friction type, providing four changes of speed, available by the use of the two levers shown. Frictions are of a patented double band type, and are made of large proportions. Four feeds ranging in geometrical progression from 0.007 inch to 0.041 inch are provided by the feeding mechanism on the head, the feeds being obtained by the turning of a dial on the feed box until the desired feed indexed thereon comes under the fixed pointer. Feeds can be automatically tripped at any position of the spindle by an adjustable trip dog acting on the worm clutch. Depth graduations are marked on the spindle, and all depths can be read from zero. The spindle has eight changes of speed ranging in geometrical progression from 13 to 300, any one of which may be thrown in without stopping the machine. The spindle is regularly bored for a No. 4 Morse taper hole. The spindle is counterbalanced and has a quick advance and return by means of the lever shown directly in front. The head is traversed along the arm through a spiral pinion and rack by means of a hand wheel located on the head to the left. The back gears are located on the head and they may be thrown in or out while the machine is running. The tapping mechanism is carried on the head between the back gears and the speed box, thus giving to the frictions the benefit of the back gear ratio,



American Radial Drill.

making possible heavy tapping operations and permitting taps to be backed out at an increased speed. The lever for starting, stopping or reversing the spindle is, as shown, under the hand wheel for moving the head along the arm, and controlled from the front of the machine. The greatest distance from the spindle to the base is 4 feet 1⅛ inches; the traverse of the

spindle is 11 inches, and that of the head on the arm is 2 feet, 3⅛ inches.

The plain table regularly supplied with this machine has a top surface of 16x26 inches, and also side surfaces, both top and side surfaces being supplied with T-slots. A worm swivelling table which can be revolved to any angle horizontally through a worm and worm wheels can be supplied. It is graduated at the point of swivelling contact. The top surface is 16x24 inches. A round table may also be supplied 24 inches in diameter, and may be fitted to either the plain or worm swivel table. It revolves by hand on a stump fitted into the other table and can be locked by a binding screw. The regular equipment of the drill consists of the machine with a cone pulley drive, plain table only, and one countershaft.

STARTING AND REGULATING RHEOSTATS FOR MACHINE TOOL DRIVES.

The accompanying cuts show a type of controller manufactured by the Cutler-Hammer Mfg. Co., of Milwaukee, Wis., and intended for the operation of machine tools or similar apparatus in which the operator is within reach of the controlling handle, the speed regulation being entirely effected by a shunt field control. In designing this controller the chief objects sought were the elimination of the possibility of the motor starting under a weakened field, the provision of a large number of field regulating points, the operation of the device with a single lever, and the returning of all parts to the "off" position in case of the cessation of current or the flow of abnormal current.

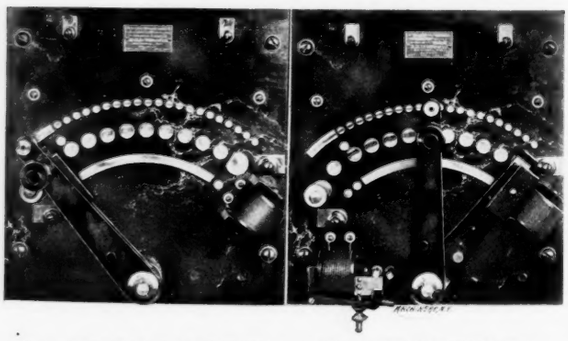


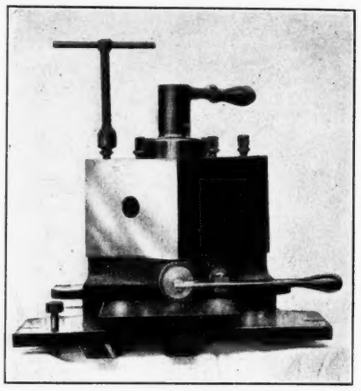
Fig. 1. Controller with Underload Release.

Fig. 2. With Overload and Underload Release.

The apparatus consists of a motor starter of standard construction, and a series of field buttons controlled by a field resistance lever mounted on the same hub post as the starter lever, and co-operating with the field starter lever. The motor is started and brought to speed, in operation, by moving the handle to the right, this handle being attached to the field regulator lever, which is mechanically connected to the starter lever so as to move them as one piece in starting the motor. During this operation of starting the field resistance is short-circuited by an auxiliary contact mounted on the starter lever, and a curved sector placed just below the armature contact. When the two levers have been moved to the position in which all resistance is cut out of the armature circuit, a keeper on the starter lever is attracted by the magnet, and the starter lever is held in this position. At this time also the auxiliary contact above referred to has left the curved sector, thus removing the short-circuit from the field resistance. The field lever is now free for movement over the field rheostat buttons, and may be left at any desired point, thus regulating the speed of the motor as desired. If the retaining magnet is de-energized either by failure of voltage, or by operation of the overload releasing device, the starter lever is released and returned to the starting position, carrying with it the field rheostat lever.

NEW LATHE CARRIAGE TURRET.

The Lodge & Shipley Machine Tool Co., Cincinnati, O., have brought out a new turret for a lathe carriage, which is here illustrated in place on the carriage. This turret was designed with the view of having rigidity commensurate with the increase of cutting power of tool steel, and yet being interchangeable with the regular compound rest. The chief departure from the ordinary standard in its construction is in the plate on which the cross slide moves. This plate is made to slide on the regular carriage dove tail, and be held in place by four bolts in the T-slots of the carriage wings. The cross slide is made with a bearing about twice as wide as the regular compound rest. The plate is slotted, permitting a cross feed nut to extend up and to attach to the cross slide so that the cross feed can be applied to the turret. The regular carriage dove tail is largely relieved of wear, since no movement of the plate takes place.



Lodge & Shipley Turret.

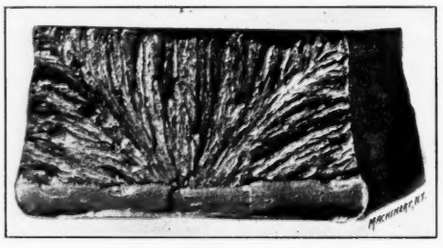
THE TRIMO MONKEY WRENCH.

The wrench here shown contains but three parts, all of which are of case-hardened, drop-forged steel. The threads of the jaw and also of the nut are rounded after the fashion of the Whitworth thread, which largely prevents the possibility of bruising them or stripping them off. The leverage of this wrench is increased in proportion to the size of the nut it is used upon, as the jaw is extended forward to engage the nut, instead of being drawn back as is the case with many monkey wrenches. Three sizes of the wrench are ready for the market, the 10, 12 and 15 inch. The wrench is constructed for strength and service, and should stand considerable strain in shop use. It is made by the Trimont Mfg. Co., Roxbury, Mass.

The Trimo Monkey Wrench.

NEW ANTI-FRICTION METAL.

A new anti-friction metal has been placed on the market by the Buda Foundry & Machine Co. of Chicago. This metal is an alloy of tin and aluminum, and has as its chief characteristic a peculiar crystalline structure which is shown clearly in the engraving. A bar of the metal was nicked and broken, revealing a fibrous formation with the fibers radiating from the surfaces of the bar. This feature is held by the manufacturers to be of great importance because they believe to have demonstrated that a metal of this formation will stand a greater crushing load and will be more durable under wear than if the fibers ran parallel with the surfaces, or if crystals

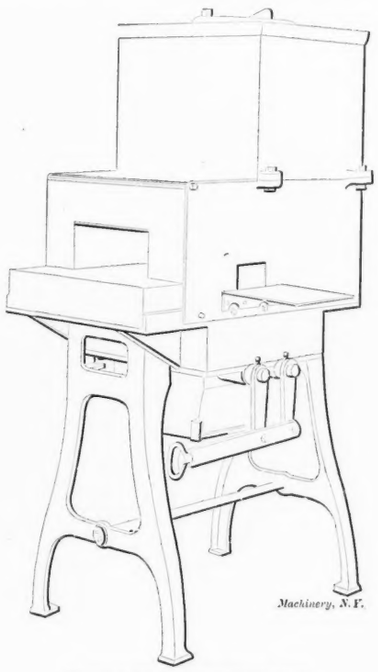


A New Anti-friction Metal.

of the more usual type were formed in the process of cooling. To illustrate the point attention is called to the fact that the end fiber of wood forms a satisfactory wearing surface for bearings, band brakes and other purposes, whereas if the wear came on the sides of the fibers the wood would splinter and be less durable. Other characteristics of the metal are that it may be repeatedly reheated without deteriorating and that it will stand the most severe shocks without becoming brittle.

THE GANTT FURNACE.

The Gantt furnace, which was designed primarily for forging and treating high grade tool steel, is manufactured by A. P. Witteman & Co., 233-237 Cherry Street, Philadelphia, Pa. It is illustrated in one of the sizes made, in the accompanying cut. For the work for which this furnace was designed it must be maintained continuously at a constant temperature,



Furnace for Treating Tool Steel.

and the steels must be heated without oxidizing. These results are accomplished in practice with the expenditure of but a small amount of fuel, the furnace rapidly being heated up to the proper degree and the temperature being readily controlled by means of regulation of the amount of blast.

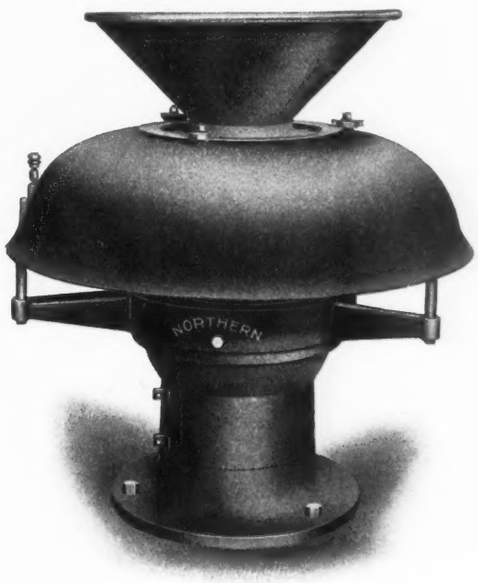
In operation, the reservoir at the top of the furnace is filled with coke or coal, which feeds the fire automatically, once the latter is started on the grate in the ordinary manner. The steel to be heated is placed in the opening in front, or in the case of the modern high speed steel where high heat is needed, in the hole in the side. The flames from the grate pass over the steel toward the front, the gases escaping through the front opening. By this method of enclosing the flame, and also in part on account of the preheating of the fuel in the reservoir, directly over the fire, the gases of combustion are fully burnt and the possibility of oxidizing the steel greatly reduced. The blast enters on the side of the furnace opposite to that shown in the cut. The blast may be easily regulated, thus maintaining a constant temperature. The fire is shaken down by means of the hand lever shown, two, or three, grates being employed. The openings of the heating chamber may be closed with fire brick when it is desired.

These furnaces are built in three standard sizes, having heating chambers of the following cross sections, size A, 9x2½ in.; size B, 14x5 in.; size C, 24x5 inches. A is used for forging, hardening and treating lathe and planer tools; it is suitable for a shop in which the amount of this work is small, and where it is not desired to run the furnace continuously. B is used for tool forging and similar high grade work when the amount is sufficient to keep one or two smiths continuously busy. This is the size shown in the illustration. By means of the small hole in the side two men may use the furnace at the same time. For small drop forgings a soft heat may be given to enough ¾-inch stock to make eight 10-inch forgings per minute all day long. As a rivet furnace it will heat without burning six ½-inch rivets each minute, or four ⅝-inch rivets, or three ¾-inch rivets. C is primarily a drop forge furnace and will heat 1¼-inch stock fast enough for six 10-inch heats per minute all day long, or four 1⅛-inch rivets per minute continuously. These furnaces may be used for a number of other purposes, among which may be mentioned that of welding.

The economy of the Gantt furnace is notable, and compares favorably with that of oil as a fuel; it is said that it can be operated with less than one half the fuel needed by most coal or coke fired furnaces. Once the reservoir is filled with coal and the draught properly regulated, no further attention need be given to the condition of the fire. No connection with flue or chimney is necessary.

ELECTRICALLY DRIVEN SAND MIXER.

The Sellers Sand Mixer here illustrated is employed in mixing foundry sands, etc. It consists of a rapidly revolving table having on its top surface a number of prongs projecting upwards. The sand is fed into the hopper in the top of the machine, from which it falls upon the revolving table and is thrown by centrifugal force from prong to prong and out against the inside of the cover or hood. It emerges from beneath the hood in a fine shower, thoroughly mixed. The ma-



Sellers Foundry Sand Mixer.

chine has a capacity of five tons per hour, which is said to be as fast as the sand can be shoveled in and taken away by two men. The mixer, which is constructed by William Sellers & Co., Philadelphia, Pa., is equipped with a Northern Variable Speed Motor built by the Northern Electrical Mfg. Co., Madison, Wis. This is a 5 H. P. motor, and operates at from 1,200 to 1,500 R. P. M. The motor equipment includes a special lubricating device. It operates from any ordinary two-wire single voltage system.

THE CORRUGATED GRINDING WHEEL.

A brief notice of a new grinding wheel manufactured by the Corrugated Grinding Wheel Co., of 5036 Hazel Avenue, Philadelphia, Pa., appeared in MACHINERY for April. This grinding wheel is illustrated herewith. The wheels have slanting corrugations or teeth on the periphery of the wheel, thus making the action that of shearing rather than grinding, which greatly increases their capacity for work. By the employment of the corrugations a second advantage is gained, that, since the corrugations are said to improve the results without regard to the hardness of the wheel, an extremely hard wheel may be used. The safety of the wheel is thereby increased. The corruga-

tions are quickly produced by a patented hand tool which requires no fixture nor previous skill of manipulation, nor removal of the wheel. The tool is passed back and forth across the face of the wheel when running.

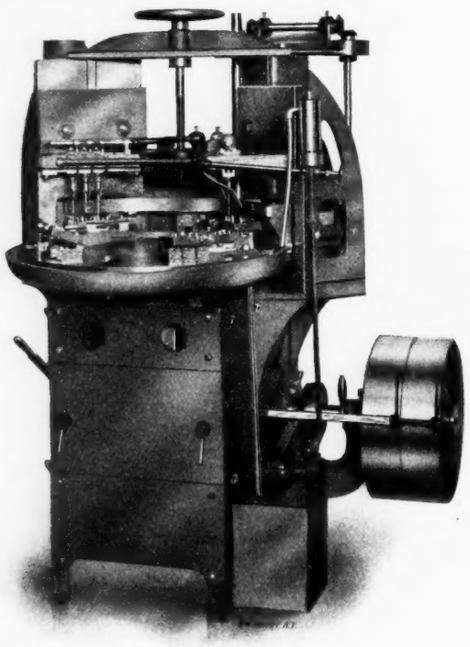
Comparative tests have shown the advantages derived from the corrugations to be considerable. These tools have been used to grind many different materials, with results which show that the corrugated wheels grind more rapidly, with less heating and with a much less tendency to glaze, than where

Grinding Wheel with Corrugated Face.

wheels of the same material, but without corrugations, have been used. Fifty tests were made by the manufacturers on a specially designed testing rig, by which a plain grinding wheel and a corrugated one were set to work grinding gray iron plate three-fourths of an inch thick, under identical conditions. The average of these tests showed that in thirty minutes the corrugated ground to a depth of 3 inches, while the wheel when not corrugated ground only to a depth of 1¼ inches, showing a net gain of 140 per cent. for the wheel after corrugation.

AUTOMATIC DRILLING MACHINE.

In the accompanying illustration is shown a new automatic drill of unusually large capacity that has recently been constructed by the National Automatic Tool Co., Dayton, Ohio. The machine is designed with two uprights, each carrying a head with a group of spindles. The work is placed on the rotating table which feeds upward against the drill spindles. The advantage of the two uprights is that holes may be drilled near together in the same piece, those coming adjacent being

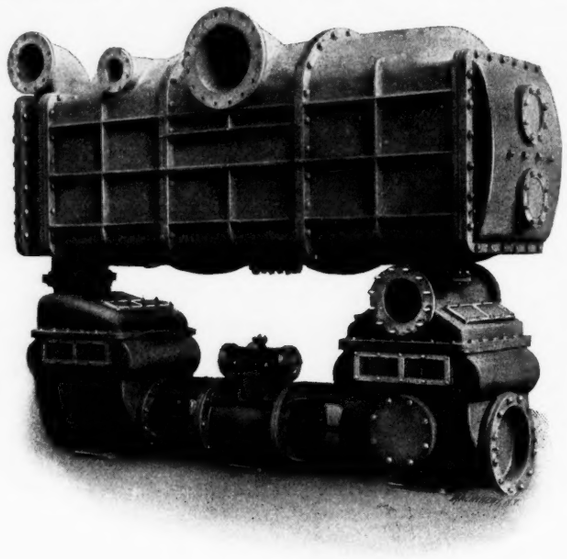


Automatic Drill for Smal Work.

drilled by different heads so there is no interference of the spindles, as would be the case if it were attempted to drill all the holes with one set of spindles. The machine is entirely automatic, the operator merely placing the work in the jigs on the table and removing it when it is completed. This size of machine will drill holes from ¾-inch down to the size corresponding to No. 72 drill. A machine of this type has drilled 90,000 holes in ten hours. The particular machine illustrated was fitted to turn out 5,500 typewriter type bars in ten hours, three holes being drilled in each bar.

THE W. H. BLAKE CONDENSER.

The W. H. Blake Steam Pump Co., Hyde Park, Mass., have started manufacturing independent jet and surface condensers, one of the latter type, intended for marine work, being illustrated herewith. The tubes are of Muntz metal, so held in the tube sheets as to allow for free expansion. The steam passes in at the top and thence across the water tubes, and finally escapes below as water of condensation, rapid condensation being aided by the introduction of baffle plates. The rectangular condenser shell is supported by the combined air and circulating pump, which is substantially made. The valve mechanism of the pump is actuated entirely by direct boiler pressure, so that the valves are therefore directly controlled at all points in the stroke. These pumps are composition fitted throughout, both the water and the air cylinders are lined, and a Tobin bronze piston rod is used.



W. H. Blake Surface Condenser.

FRESH FROM THE PRESS.

Mr. Alexander C. Humphreys, Consulting Engineer and President of Stevens Institute of Technology, has introduced at the Institute a course of lectures upon what he terms business engineering. He contends that the successful mechanical engineer must have an appreciation of the commercial side of engineering and is attempting to give his students a knowledge of the fundamentals of business practice as well as of engineering practice. He has issued lecture notes on some of the business features of engineering practice which we presume are intended for his students, but are none the less valuable to the outsider. We have received a copy for review and can commend the book heartily, but unfortunately no price was stated.

GAS ENGINES AND PRODUCER GAS PLANTS is the title of a book by R. E. Mathot, M.E., published by the Norman W. Henley Publishing Co., 132 Nassau St., New York. 314 8-vo. pages illustrated. Price $2.50.

This work is a translation from the original French manuscript by Waldemar B. Kaempffert, with a preface by Dugald Clerk, the well-known English authority upon gas engine producers. The subject of power plants in which gas producers and gas engines are used is one of increasing importance and one that is being investigated extensively by engineers. This book treats the subject in a simple manner, describing the process of gas manufacture and the auxiliary apparatus used in gas producer plants. It deals mainly with engines and producers of small and medium size, discussing quite fully practical points regarding the operation of such plants. Ten chapters of the book are devoted to gas engines and their details and five chapters to gas producers of different types.

STEAM PIPES. . THEIR DESIGN AND CONSTRUCTION. By William H. Booth. Published by the Norman W. Henley Publishing Co., 132 Nassau St., New York. 187 8-vo. pages illustrated. Price $2.

Mr. Booth, who is a well-known English consulting engineer, has written extensively for the technical press, both in this country and in England. This is the first book that we know of to be published on the subject of steam pipes, and the information that he has gathered in regard to piping for power plants will prove valuable to engineers who have such plants to design. There are numerous tables, and the various practical points that must be regarded in laying out and operating a power plant are duly considered. Mr. Booth, the writer, says in the preface that the engineer will refer in vain to his various text books for information upon steam piping, and the object of his treatise is to supply the deficiency. He furnishes also tables of sizes of valves which will prove useful.

THE TEMPERATURE-ENTROPY DIAGRAM. By Charles W. Berry. Published by John Wiley & Sons, New York. 134 12-mo. pages illustrated. Price $1.25.

The Temperature-Entropy Diagram is gaining in favor as a means for analyzing the thermal changes taking place in gases and vapors